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Human N-Methyl-D-Aspartate Receptor Subunits, Nucleic Acids Encoding Same and Uses Therefor

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Human N-Methyl-D-Aspartate Receptor Subunits, Nucleic Acids Encoding Same and Uses Therefor

This application is a continuation-in-part of United States Serial No. 08/052,449, filed April 20, 1993, now pending.

The present invention relates to nucleic acids and receptor proteins encoded thereby. Invention nucleic acids encode novel human N-methyl-D-aspartate (NMDA) receptor subunits. The invention also relates to methods for making such receptor subunits and for using the receptor proteins in assays designed to identify and characterize compounds which affect the function of such receptors, e.g., agonists and antagonists of NMDA receptors.

BACKGROUND OF THE INVENTION

The amino acid L-glutamate is a major excitatory neurotransmitter in the mammalian central nervous system. Anatomical, biochemical and electrophysiological analyses suggest that glutamatergic systems are involved in a broad array of neuronal processes, including fast excitatory synaptic transmission, regulation of neurotransmitter releases, long-term potentiation, learning and memory, developmental synaptic plasticity, hypoxic-ischemic damage and neuronal cell death, epileptiform seizures, as well as the pathogenesis of several neurodegenerative disorders. See generally, Monaghan et al., Ann. Rev. Pharmacol. Toxicol. 29:365-402 (1980). This extensive repertoire of functions, especially those related to learning, neurotoxicity and neuropathology, has stimulated recent attempts to describe and define the mechanisms through which glutamate exerts its effects.

Currently, glutamate receptor classification schemes are based on pharmacological criteria. Glutamate

has been observed to mediate its effects through receptors that have been categorized into two main groups: ionotropic and metabotropic. Ionotropic glutamate receptors contain integral cation-specific, ligand-gated ion channels, whereas metabotropic glutamate receptors are G-protein-coupled receptors that transduce extracellular signals via activation of intracellular second messenger systems. Ionotropic receptors are further divided into at least two categories based on the pharmacological and functional properties of the receptors. The two main types of ionotropic receptors are N-methyl-D-aspartic acid (NMDA) and kainic acid (KA)/α-amino-3-hydroxy-5-methyl-isoxazole-4-propionic acid (AMPA), formerly called the quisqualic acid, or QUIS, receptor. While the metabotropic receptors bind to some of the same ligands that bind to ionotropic glutamate receptors, the metabotropic receptors alter synaptic physiology via GTP-binding proteins and second messengers such as cyclic AMP, cyclic GMP, diacylglycerol, inositol 1,4,5-triphosphate and calcium [Gundersen et al., Proc. R. Soc. London Ser. 221:127 (1984); Sladeczek et al., Nature 317:717 (1985); Nicoletti et al., J. Neurosci. 6:1905 (1986); Sugiyama et al., Nature 325:531 (1987)].

The electrophysiological and pharmacological properties of the glutamate receptors have been studied using animal tissues and cell lines, as well as recombinantly produced non-human receptors, as the source of such receptors. The value of such studies for application to the development of human therapeutics has been limited by the availability of only non-human receptor subunits. Moreover, it is only recently that the characteristics and structure of glutamate receptors have been investigated at the molecular level. The majority of such investigation has, however, been carried out in non-human species. Because of the potential physiological and pathological significance of glutamate receptors, it would be desirable (for example, for drug screening assays) to

have available human sequences (i.e., DNA, RNA, proteins) which encode representative members of the various glutamate receptor subtypes. The availability of such human sequences will also enable the investigation of receptor distribution in humans, the correlation of specific receptor modification with the occurrence of various disease states, etc.

BRIEF DESCRIPTION OF THE INVENTION

The present invention discloses novel nucleic acids encoding NMDA receptor protein subunits and the proteins encoded thereby. In a particular embodiment the novel nucleic acids encode NMDAR1 and NMDAR2 subunits of human NMDA receptors. More specifically, the invention nucleic acids encode NMDAR1, NMDAR2A, NMDAR2B, NMDAR2C and NMDAR2D subunits that contribute to the formation of NMDA-activated cation-selective ion channels. In addition to being useful for the production of NMDA receptor subunit proteins, these nucleic acids are also useful as probes, thus enabling those skilled in the art, without undue experimentation, to identify and isolate nucleic acids encoding related receptor subunits.

Functional glutamate receptors can be assembled, in accordance with the present invention, from a plurality of NMDA receptor subunit proteins of one type (homomeric) or from combinations of subunit proteins of different types (heteromeric).

In addition to disclosing novel NMDA receptor protein subunits, the present invention also comprises methods for using such receptor subunits to identify and characterize compounds which affect the function of such receptors, e.g., agonists, antagonists, and modulators of glutamate receptor function. The invention also comprises

methods for determining whether unknown protein(s) are functional as NMDA receptor subunits.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic representation of various human NMDAR1 clones of the invention, with partial restriction maps of each clone. The clones are aligned and the differences in the DNAs (i.e., deletions and insertions), relative to clone NMDA10, are indicated. Translation initiation and termination sites are represented by a "V" and a "*", respectively. Insertions are marked as inverted triangles, deletions are indicated by spaces in the boxes. The numbers above the insertions and deletions refer to the number of nucleotides inserted or deleted relative to NMDA10.

Figure 2 is a schematic representation of cDNAs encoding full-length human NMDAR1 subunit subtypes of the invention, with partial restriction maps of each DNA. The full-length cDNAs are constructed by ligation of appropriate portions of the clones shown in Figure 1. Regions of each full-length cDNA composed of nucleotide sequences corresponding to a particular clone are distinguished as solid, striped, cross-hatched or open boxes.

Figure 3 presents the entire nucleotide sequence of construct NMDAR1A (see Sequence ID No. 1) with the following information added for ease of comparison of the splice variations of the NMDAR1 subunit transcript: lowercase letters indicate 5' untranslated sequence and the 3' untranslated sequence of the NMDAR1 splice variant shown in Sequence ID No. 1 (in some of the other splice variants, this 3' untranslated sequence is actually coding sequence); uppercase letters indicate coding sequence; the translation initiation codon is identified by the word "START" whereas

the three different translation termination codons (TGA) used in the different splice variants are identified by small boxes; significant restriction enzyme sites used in preparing full-length variant constructs are identified by name above the sites; the location of a 63-bp insertion (see Sequence ID No. 3) that exists in some of the variants is marked as "63 bp INSERT"; the nucleotide sequences that are deleted from some of the variants are boxed and labeled as "204 bp DELETION," "363 bp DELETION," and "1087 bp DELETION."

Figure 4 is a schematic representation of various human NMDAR2C clones of the invention, with partial restriction maps of each clone. The clones are aligned and the differences in the DNAs relative to clone NMDA26 are indicated in the same manner as done in Figure 1.

Figure 5 is a schematic representation of full-length human NMDAR2C subunit subtypes of the invention, with partial restriction maps of each DNA. The full-length cDNAs are constructed by ligation of appropriate portions of the clones shown in Figure 4. Regions of each full-length cDNA composed of nucleotide sequences corresponding to a particular clone are distinguished as solid, striped, cross-hatched or open boxes.

Figure 6 presents restriction maps of CMV promoter-based vectors pCMV-T7-2 and pCMV-T7-3.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, there are provided isolated nucleic acids encoding human N-methyl-D-aspartate (NMDA) receptor subunit(s). In one aspect of the present invention, nucleic acids encoding NMDA receptor subunit(s) of the NMDAR1 subtype are provided. In another aspect, nucleic acids encoding NMDA

receptor subunit(s) of the NMDAR2 subtype are provided. In a further aspect, eukaryotic cells containing such nucleic acids, and eukaryotic cells expressing such nucleic acids are provided.

Also provided are protein(s) encoded by the above-described nucleic acids, as well as antibodies generated against the protein(s). In other aspects of the present invention, there are provided nucleic acid probes comprising at least NMDA receptor subunit-selective portions of the above-described nucleic acids.

As employed herein, the phrase "human N-methyl-D-aspartate (NMDA) receptor subunit(s)" refers to recombinantly produced (i.e., isolated or substantially pure) proteins which participate in the formation of a voltage-sensitive cation-selective channel activated by exposure to NMDA, and having at least one transmembrane domain, a large N-terminal extracellular domain, and the like, including variants thereof encoded by mRNA generated by alternative splicing of a primary transcript, and further including fragments thereof which retain one or more of the above properties.

Use of the phrase "recombinantly produced", "isolated" or "substantially pure" in the present specification and claims as a modifier of DNA, RNA, polypeptides or proteins means that the DNA, RNA, polypeptides or proteins so designated have been produced in such form by the hand of man, and thus are separated from their native *in vivo* cellular environment. As a result of this human intervention, the recombinant DNAs, RNAs, polypeptides and proteins of the invention are useful in ways that the DNAs, RNAs, polypeptides or proteins as they naturally occur are not, such as identification of selective drugs or compounds.

The term "functional", when used herein as a modifier of receptor protein(s) of the present invention, means that binding of NMDA (or NMDA-like) ligand to receptors comprising the protein(s) causes the receptor "ion channels" to open. This allows cations, particularly Ca^{2+}, as well as Na^{+} and K^{+}, to move across the membrane. Stated another way, "functional" means that a signal is generated as a consequence of agonist activation of receptor protein(s).

As used herein, a splice variant refers to variant NMDA receptor subunit-encoding nucleic acid(s) produced by differential processing of primary transcript(s) of genomic DNA, resulting in the production of more than one type of mRNA. cDNA derived from differentially processed primary transcript will encode NMDA receptor subunits that have regions of complete amino acid identity and regions having different amino acid sequences. Thus, the same genomic sequence can lead to the production of multiple, related mRNAs and proteins. Both the resulting mRNAs and proteins are referred to herein as "splice variants".

Accordingly, also contemplated within the scope of the present invention are DNAs that encode NMDA receptor subunits as defined above, but that by virtue of degeneracy of the genetic code do not necessarily hybridize to the disclosed DNA under specified hybridization conditions. Such subunits also contribute to the formation of functional receptor, as assessed by methods described herein or known to those of skill in the art, with one or more additional NMDA receptor subunits of the same or different type (the presence of additional subunits of a different type is optional when said subunit is an NMDAR1 subunit). Typically, unless an NMDA receptor subunit is encoded by RNA that arises from alternative splicing (i.e., a splice variant), NMDA receptor subunit-encoding DNA and

the NMDA receptor subunit encoded thereby share substantial sequence homology with at least one of the NMDA receptor subunit DNAs (and proteins encoded thereby) described herein. It is understood that DNA or RNA encoding a splice variant may share less than 90% overall sequence homology with the DNA or RNA provided herein, but include regions of nearly 100% homology to a DNA fragment described herein, and encode an open reading frame that includes start and stop codons and encodes a functional NMDA receptor subunit.

As employed herein, the phrase "NMDA receptor subunit(s) of the NMDAR1 subtype" refers to proteins which, by hydrophobicity analysis of deduced amino acid sequences, are believed to contain four or more putative transmembrane domains, preceded by a large extracellular N-terminal domain. The amino acid sequence typically contains possible phosphorylation sites for Ca^{2+}/calmodulin-dependent protein kinase type II and protein kinase C [see, for example, Kemp et al. (1990) Trends in Biological Science Vol. 15:342-346; Kishimoto et al. (1985) J. Biol. Chem. Vol. 260:12492-12499; Whittemore et al. (1993) Nature 364:70-73]. (These protein kinases reportedly play a crucial role in induction and maintenance of long term potentiation.)

The putative TMII segment (i.e., second transmembrane domain) is typically flanked by a glutamic acid residue at the extracellular side and a stretch of glutamic acid residues at the cytoplasmic side. This segment contains an asparagine residue believed to be responsible for high Ca^{2+} permeability of the NMDAR channel. For a summary of NMDAR properties, see Ben-Ari et al., in TINS 15:333-339 (1992), especially at p. 334.

Exemplary DNA sequences encoding human NMDAR1 subunits are represented by nucleotides which encode substantially the same amino acid sequence as set forth in

Sequence ID Nos. 2, 2E, 2F, 2G, 2H, 2I, 2J, 2K, 2L, 2M, 2N, or 2P. Presently preferred sequences encode substantially the same amino acid sequence as set forth in Sequence ID Nos. 2, 2E, 2F, 2G, 2H, 2I or 2P.

Exemplary DNA can alternatively be characterized as those nucleotide sequences which encode a human NMDAR1 subunit and hybridize under high stringency conditions to substantially the entire sequence of any one of Sequence ID Nos. 1, 1A, 1B, 1C, 1D, 1E, 1F, 1G, 1H, 1I, 1J, 1K, 1L, 1M, 1N, or 1P, or substantial portions thereof (i.e., typically at least 25-30 nucleotides thereof); preferably exemplary DNA will hybridize under high stringency conditions to substantially the entire sequence of any one of Sequence ID Nos. 1, 1E, 1F, 1G, 1H, 1I or 1P, or substantial portions thereof.

Stringency of hybridization is used herein to refer to conditions under which polynucleic acid hybrids are stable. As known to those of skill in the art, the stability of hybrids is reflected in the melting temperature (T_m) of the hybrids. T_m can be approximated by the formula:

$$81.5°C - 16.6(\log_{10}[Na^+]) + 0.41(\%G+C) - 600/l,$$

where l is the length of the hybrids in nucleotides. T_m decreases approximately 1-1.5°C with every 1% decrease in sequence homology. In general, the stability of a hybrid is a function of sodium ion concentration and temperature. Typically, the hybridization reaction is performed under conditions of lower stringency, followed by washes of varying, but higher, stringency. Reference to hybridization stringency relates to such washing conditions. Thus, as used herein:

(1) HIGH STRINGENCY conditions, with respect to fragment hybridization, refers to conditions that permit hybridization of only those nucleic acid sequences that form stable hybrids in 0.018M NaCl at 65°C (i.e., if a hybrid is not stable in 0.018M NaCl at 65°C, it will not be stable under high stringency conditions, as contemplated herein). High stringency conditions can be provided, for example, by hybridization in 50% formamide, 5X Denhart's solution, 5X SSPE, 0.2% SDS at 42°C, followed by washing in 0.1X SSPE, and 0.1% SDS at 65°C;

(2) MODERATE STRINGENCY conditions, with respect to fragment hybridization, refers to conditions equivalent to hybridization in 50% formamide, 5X Denhart's solution, 5X SSPE, 0.2% SDS at 42°C, followed by washing in 0.2X SSPE, 0.2% SDS, at 65°C;

(3) LOW STRINGENCY conditions, with respect to fragment hybridization, refers to conditions equivalent to hybridization in 10% formamide, 5X Denhart's solution, 6X SSPE, 0.2% SDS at 42°C, followed by washing in 1X SSPE, 0.2% SDS, at 50°C; and

(4) HIGH STRINGENCY conditions, with respect to oligonucleotide (i.e., synthetic DNA $\leq$ about 30 nucleotides in length) hybridization, refers to conditions equivalent to hybridization in 10% formamide, 5X Denhart's solution, 6X SSPE, 0.2% SDS at 42°C, followed by washing in 1X SSPE, and 0.2% SDS at 50°C.

It is understood that these conditions may be duplicated using a variety of buffers and temperatures and that they are not necessarily precise.

Denhart's solution and SSPE (see, e.g., Sambrook, Fritsch, and Maniatis, in: Molecular Cloning, A Laboratory Manual, Cold Spring Harbor Laboratory Press, 1989) are well known to those of skill in the art as are other suitable hybridization buffers. For example, SSPE is pH 7.4 phosphate-buffered 0.18M NaCl. SSPE can be prepared, for example, as a 20X stock solution by dissolving 175.3 g of NaCl, 27.6 g of NaH_2PO_4 and 7.4 g EDTA in 800 ml of water, adjusting the pH to 7.4, and then adding water to 1 liter. Denhart's solution (see, Denhart (1966) Biochem. Biophys. Res. Commun. 23:641) can be prepared, for example, as a 50X stock solution by mixing 5 g Ficoll (Type 400, Pharmacia LKB Biotechnology, INC., Piscataway, NJ), 5 g of polyvinylpyrrolidone, 5 g bovine serum albumin (Fraction V; Sigma, St. Louis, MO) water to 500 ml and filtering to remove particulate matter.

Especially preferred sequences are those which have substantially the same nucleotide sequence as the coding sequences in any one of Sequence ID Nos. 1, 1E, 1F, 1G, 1H, 1I, 1J, 1K, 1L, 1M, 1N, or 1P; with those having substantially the same sequence as the coding sequence in Sequence ID Nos. 1, 1E, 1F, 1G, 1H, 1I or 1P being most preferred.

As used herein, the phrase "substantial sequence homology" refers to nucleotide sequences which share at least about 90% identity, and amino acid sequences which typically share more than 95% amino acid identity (>99% amino acid identity when dealing with NMDAR1 subunits). It is recognized, however, that proteins (and DNA or mRNA encoding such proteins) containing less than the above-described level of homology arising as splice variants or

that are modified by conservative amino acid substitutions (or substitution of degenerate codons) are contemplated to be within the scope of the present invention.

As used herein, the phrase "substantially the same" refers to the nucleotide sequences of DNA, the ribonucleotide sequences of RNA, or the amino acid sequences of protein, that have slight and non-consequential sequence variations from the actual sequences disclosed herein. Species that are "substantially the same" are considered to be equivalent to the disclosed sequences, and as such are within the scope of the appended claims. In this regard, "slight and non-consequential sequence variations" mean that sequences that are substantially the same as the DNA, RNA, or proteins disclosed and claimed herein, are functionally equivalent to the human-derived sequences disclosed and claimed herein. Functionally equivalent sequences will function in substantially the same manner to produce substantially the same compositions as the human-derived nucleic acid and amino acid compositions disclosed and claimed herein. In particular, functionally equivalent DNAs encode human-derived proteins that are the same as those disclosed herein or that have conservative amino acid variations, such as substitution of a non-polar residue for another non-polar residue or a charged residue for a similarly charged residue. These changes include those recognized by those of skill in the art as those that do not substantially alter the tertiary structure of the protein.

As employed herein, the phrase "NMDA receptor subunit(s) of the NMDAR2 subtype" refers to proteins which have a large putative extracellular domain at the amino-terminal region. Otherwise, the deduced structure of NMDAR2 subunits displays the same general characteristics as the NMDAR1 subunit structure. A notable typical exception is that the negatively charged glutamic acid

residues that are generally present in the putative TMII segment of NMDAR1 subunits are generally absent from the TMII segment of NMDAR2. Instead, NMDAR2 subunits may contain a positively charged lysine residue in TMII. Unlike NMDAR1 subunits, NMDAR2 subunits generally do not form homomeric NMDA receptors. Moreover, the amino acid sequences of NMDAR1 and NMDAR2 subunits are generally less than 50% identical, with identities of less than 30% typically observed.

NMDAR2 subunits contemplated by the present invention include NMDAR2A, NMDAR2B, NMDAR2C and NMDAR2D types of subunits. Exemplary DNA sequences encoding human NMDAR2A subunits, or portions thereof, are represented by nucleotides which encode substantially the same amino acid sequence as set forth in Sequence ID No. 11, or substantially the same amino acid sequence as that encoded by the NMDAR2A-encoding portion of clone NMDA57, deposited with the ATCC under accession number 75442.

The deposited clone has been deposited at the American Type Culture Collection (ATCC), 12301 Parklawn Drive, Rockville, Maryland, U.S.A. 20852, under the terms of the Budapest Treaty on the International Recognition of Deposits of Microorganisms for Purposes of Patent Procedure and the Regulations promulgated under this Treaty. Samples of the deposited material are and will be available to industrial property offices and other persons legally entitled to receive them under the terms of the Treaty and Regulations and otherwise in compliance with the patent laws and regulations of the United States of America and all other nations or international organizations in which this application, or an application claiming priority of this application, is filed or in which any patent granted on any such application is granted. In particular, upon issuance of a U.S. patent based on this or any application claiming priority to or incorporating this application by

reference thereto, all restriction upon availability of the deposited material will be irrevocably removed.

Exemplary human NMDAR2A subunit-encoding DNAs can alternatively be characterized as those nucleotide sequences which hybridize under high stringency conditions to substantially the entire sequence of Sequence ID No. 10, or substantial portions thereof (i.e., typically at least 25-30 nucleotides thereof), or the NMDAR2A-encoding portion of clone NMDA57 (ATCC accession No. 75442). Especially preferred sequences encoding human NMDAR2A subunits are those which have substantially the same nucleotide sequence as the coding sequence of Sequence ID No. 10, or those which contain substantially the same nucleotide sequence as the coding sequence in the NMDAR2A-encoding portion of clone NMDA57.

Exemplary DNA sequences encoding human NMDAR2B subunits are represented by nucleotides which encode substantially the same amino acid sequence as set forth in Sequence ID No. 14. Exemplary DNAs can alternatively be characterized as those nucleotide sequences which encode a human NMDAR2B subunit and hybridize under high stringency conditions to substantially the entire sequence of Sequence ID No. 13, or substantial portions thereof (i.e., typically at least 25-30 nucleotides thereof). Especially preferred NMDAR2B-encoding sequences are those which have substantially the same nucleotide sequence as the coding sequence in Sequence ID No. 13.

Exemplary DNA sequences encoding human NMDAR2C subunits are represented by nucleotides which encode substantially the same amino acid sequence as set forth in Sequence ID Nos. 6, 6E, 6F, 6G, 6H or 6I.

Exemplary DNAs can alternatively be characterized as those nucleotide sequences which encode a human NMDAR2C

subunit and hybridize under high stringency conditions to substantially the entire sequence of any one of Sequence ID Nos. 5, 5A, 5B, 5C, 5D, 5E, 5F, 5G, 5H, or 5I, or substantial portions thereof (i.e., typically at least 25-30 nucleotides thereof); preferably exemplary DNA will hybridize under high stringency conditions to substantially the entire sequence of any one of Sequence ID Nos. 5, 5E, 5F, or 5G, or substantial portions thereof.

Especially preferred NMDAR2C-encoding sequences are those which have substantially the same nucleotide sequence as the coding sequences in any one of Sequence ID Nos. 5, 5E, 5F, 5G, 5H or 5I; with those having substantially the same sequence as the coding sequences in Sequence ID Nos. 5, 5E, 5F, or 5G being most preferred.

Exemplary DNA sequences encoding human NMDAR2D subunits are represented by nucleotides which encode substantially the same amino acid sequence as set forth in Sequence ID No. 16. Exemplary DNAs can alternatively be characterized as those nucleotide sequences which encode a human NMDAR2D subunit and hybridize under high stringency conditions to substantially the entire sequence of Sequence ID No. 15, or substantial portions thereof (i.e., typically at least 25-30 nucleotides thereof). Especially preferred NMDAR2D-encoding sequences are those which have substantially the same nucleotide sequence as the coding sequence in Sequence ID No. 15.

DNA encoding human NMDA receptor subunits may be isolated by screening suitable human cDNA or human genomic libraries under suitable hybridization conditions with DNA disclosed herein (including nucleotides derived from any of SEQ ID Nos. 1, 1A-1P, 5, 5A-5I, 10, 13 or 15). Suitable libraries can be prepared from neuronal tissue samples, e.g., hippocampus and cerebellum tissue, cell lines, and the like. For example, the library can be screened with a

portion of DNA including substantially the entire subunit-encoding sequence thereof, or the library may be screened with a suitable probe.

As used herein, a probe is single-stranded DNA or RNA that has a sequence of nucleotides that includes at least 14 contiguous bases that are the same as (or the complement of) any 14 or more contiguous bases set forth in any of SEQ ID Nos. 1, 1A-1P, 5, 5A-5I, 10, 13 or 15. Preferred regions from which to construct probes include 5' and/or 3' coding sequences, sequences predicted to encode transmembrane domains, sequences predicted to encode cytoplasmic loops, signal sequences, NMDA binding sites, and the like.

Either the full-length cDNA clones or fragments thereof can be used as probes, preferably labeled with suitable label means for ready detection. When fragments are used as probes, preferably the DNA sequences will be from the carboxyl end-encoding portion of the DNA, and most preferably will include predicted transmembrane domain-encoding portions of the DNA sequence (the domains can be predicted based on hydropathy analysis of the deduced amino acid sequence using, for example, the method of Kyte and Doolittle (1982), J. Mol. Biol. Vol. 157:105). These probes can be used, for example, for the identification and isolation of additional members of the glutamate receptor family.

As a particular application of the invention sequences, genetic screening can be carried out using the nucleotide sequences of the invention as probes. Thus, nucleic acid samples from patients having neuropathological conditions suspected of involving alteration/modification of any one or more of the glutamate receptors can be screened with appropriate probes to determine if any abnormalities exist with respect to any of the endogenous

glutamate receptors. Similarly, patients having a family history of disease states related to glutamate receptor dysfunction can be screened to determine if they are also predisposed to such disease states.

In accordance with another embodiment of the present invention, there is provided a method for identifying DNA encoding human N-methyl-D-aspartate (NMDA) receptor protein subunit(s), said method comprising:

contacting human DNA with a nucleic acid probe as described above, wherein said contacting is carried out under high stringency hybridization conditions, and

identifying DNA(s) which hybridize to said probe.

After screening the library, positive clones are identified by detecting a hybridization signal; the identified clones are characterized by restriction enzyme mapping and/or DNA sequence analysis, and then examined, by comparison with the sequences set forth herein to ascertain whether they include DNA encoding a complete NMDA receptor subunit (i.e., if they include translation initiation and termination codons). If the selected clones are incomplete, they may be used to rescreen the same or a different library to obtain overlapping clones. If the library is genomic, then the overlapping clones may include exons and introns. If the library is a cDNA library, then the overlapping clones will include an open reading frame. In both instances, complete clones may be identified by comparison with the DNA and encoded proteins provided herein.

Complementary DNA clones encoding various human NMDA receptor subunits (e.g., NMDAR1, NMDAR2A, NMDAR2B, NMDAR2C, NMDAR2D) have been isolated. Each type of subunit appears to be encoded by a different gene. The DNA clones provided herein may be used to isolate genomic clones encoding each type of subunit and to isolate any splice

variants by screening libraries prepared from different neural tissues. Nucleic acid amplification techniques, which are well known in the art, can be used to locate DNA encoding splice variants of human NMDA receptor subunits. This is accomplished by employing oligonucleotides based on DNA sequences surrounding divergent sequence(s) as primers for amplifying human RNA or genomic DNA. Size and sequence determinations of the amplification products can reveal the existence of splice variants. Furthermore, isolation of human genomic DNA sequences by hybridization can yield DNA containing multiple exons, separated by introns, that correspond to different splice variants of transcripts encoding human NMDA receptor subunits.

It has been found that not all subunits (and variants thereof) are expressed in all neural tissues or in all portions of the brain. Thus, in order to isolate cDNA encoding a particular subunit or splice variants thereof, it is preferable to screen libraries prepared from different neuronal or neural tissues. Preferred tissues to use as sources of nucleic acids for preparing libraries to obtain DNA encoding each subunit include: hippocampus to isolate human NMDAR1-encoding DNAs; hippocampus, cerebellum and fetal brain to isolate NMDAR2-encoding DNAs; and the like.

Once DNA encoding a subunit has been isolated, ribonuclease (RNase) protection assays can be employed to determine which tissues express mRNA encoding a particular NMDAR subunit subtype or variant. These assays provide a sensitive means for detecting and quantitating an RNA species in a complex mixture of total cellular RNA. The subunit DNA is labeled and hybridized with cellular RNA. If complementary mRNA is present in the cellular RNA, a DNA-RNA hybrid results. The RNA sample is then treated with RNase, which degrades single-stranded RNA. Any RNA-DNA hybrids are protected from RNase degradation and can be

visualed by gel electrophorsis and autoradiography. *In situ* hybridization techniques can also be used to determine which tissues express mRNA encoding a particular NMDAR subunit. The labeled subunit DNAs are hybridized to different brain region slices to visualize subunit mRNA expression.

The distribution of expression of some human NMDA receptor subunits may differ from the distribution of such receptors in rat. For example, RNA encoding the rat NMDAR2C subunit is abundant in rat cerebellum, but is not abundant in rat hippocampus [see, e.g., Monyer et al., Science 256:1217-1221 (1992)]. Numerous human NMDAR2C clones were ultimately obtained, however, from a human hippocampus library. Thus, the distribution of some NMDA receptor subunits in humans and rats appears to be different.

The above-described nucleotide sequences can be incorporated into vectors for further manipulation. As used herein, vector (or plasmid) refers to discrete elements that are used to introduce heterologous DNA into cells for either expression or replication thereof. Selection and use of such vehicles are well within the skill of the artisan.

An expression vector includes vectors capable of expressing DNAs that are operatively linked with regulatory sequences, such as promoter regions, that are capable of effecting expression of such DNA fragments. Thus, an expression vector refers to a recombinant DNA or RNA construct, such as a plasmid, a phage, recombinant virus or other vector that, upon introduction into an appropriate host cell, results in expression of the cloned DNA. Appropriate expression vectors are well known to those of skill in the art and include those that are replicable in eukaryotic cells and/or prokaryotic cells and those that

remain episomal or those which integrate into the host cell genome. Presently preferred plasmids for expression of invention NMDA receptor subunits in eukaryotic host cells, particularly mammalian cells, include cytomegalovirus (CMV) promoter-containing vectors such as pCMV-T7-2 or pCMV-T7-3 (see Figure 6), pMMTVT7(+) or pMMTVT7(-) (modified versions of pMAMneo (Clontech, Palo Alto, CA), prepared as described herein), pcDNA1, and the like.

As used herein, a promoter region refers to a segment of DNA that controls transcription of DNA to which it is operatively linked. The promoter region includes specific sequences that are sufficient for RNA polymerase recognition, binding and transcription initiation. This portion of the promoter region is referred to as the promoter. In addition, the promoter region includes sequences that modulate this recognition, binding and transcription initiation activity of RNA polymerase. These sequences may be *cis* acting or may be responsive to *trans* acting factors. Promoters, depending upon the nature of the regulation, may be constitutive or regulated. Exemplary promoters contemplated for use in the practice of the present invention include the SV40 early promoter, the cytomegalovirus (CMV) promoter, the mouse mammary tumor virus (MMTV) steroid-inducible promoter, Moloney murine leukemia virus (MMLV) promoter, and the like.

As used herein, the term "operatively linked" refers to the functional relationship of DNA with regulatory and effector sequences of nucleotides, such as promoters, enhancers, transcriptional and translational stop sites, and other signal sequences. For example, operative linkage of DNA to a promoter refers to the physical and functional relationship between the DNA and the promoter such that the transcription of such DNA is initiated from the promoter by an RNA polymerase that specifically recognizes and binds to the promoter, and

transcribes the DNA. In order to optimize expression and/or *in vitro* transcription, it may be necessary to remove, add or alter 5' and/or 3' untranslated portions of the clones to eliminate extra, potential inappropriate alternative translation initiation (i.e., start) codons or other sequences that may interfere with or reduce expression, either at the level of transcription or translation. Alternatively, consensus ribosome binding sites (see, for example, Kozak (1991) J. Biol. Chem. 266:19867-19870) can be inserted immediately 5' of the start codon and may enhance expression. Likewise, alternative codons, encoding the same amino acid, can be substituted for coding sequences of the NMDAR subunits in order to enhance transcription (e.g., the codon preference of the host cells can be adopted, the presence of G-C rich domains can be reduced, and the like). Furthermore, for potentially enhanced expression of NMDA receptor subunits in amphibian oocytes, the subunit coding sequence can optionally be incorporated into an expression construct wherein the 5'- and 3'-ends of the coding sequence are contiguous with *Xenopus* β-globin gene 5' and 3' untranslated sequences, respectively. For example, NMDA receptor subunit coding sequences can be incorporated into vector pSP64T (see Krieg and Melton (1984) in Nucleic Acids Research 12:7057-7070), a modified form of pSP64 (available from Promega, Madison, WI). The coding sequence is inserted between the 5' end of the β-globin gene and the 3' untranslated sequences located downstream of the SP6 promoter. *In vitro* transcripts can then be generated from teh resulting vector. The desirability of (or need for) such modification may be empirically determined.

As used herein, expression refers to the process by which polynucleic acids are transcribed into mRNA and translated into peptides, polypeptides, or proteins. If the polynucleic acid is derived from genomic DNA,

expression may, if an appropriate eukaryotic host cell or organism is selected, include splicing of the mRNA.

Particularly preferred vectors for transfection of mammalian cells are the pSV2dhfr expression vectors, which contain the SV40 early promoter, mouse dhfr gene, SV40 polyadenylation and splice sites and sequences necessary for maintaining the vector in bacteria, cytomegalovirus (CMV) promoter-based vectors such as pCMV-T7-2 and pCMV-T7-3 (described herein) or pCDNA1 (Invitrogen, San Diego, CA), and MMTV promoter-based vectors such as pMMTVT7(+) or pMMTVT7(-), described herein.

Full-length DNAs encoding human NMDA receptor subunits have been inserted into vectors pcDNA1, pMMTVT7(+), pCMV-T7-2 and pCMV-T7-3. pCMV-T7-2 is a pUC19-based mammalian cell expression vector containing the CMV promoter/enhancer, SV40 splice/donor sites located immediately downstream of the promoter, a T7 bacteriophage RNA polymerase promoter positioned downstream of the splice sites, followed by an SV40 polyadenylation signal and a polylinker between the T7 promoter and the polyadenylation signal. Placement of NMDA receptor subunit DNA between the CMV promoter and SV40 polyadenylation signal should provide for constitutive expression of the foreign DNA in a mammalian host cell transfected with the construct. Plasmid pCMV-T7-3 is identical to pCMV-T7-2 except that the order of restriction enzyme sites in the polylinker is reversed.

Vectors pMMTVT7(+) and pMMTVT7(-) were prepared by modifying vector pMAMneo (Clontech, Palo Alto, CA). pMAMneo is a mammalian expression vector that contains the Rous Sarcoma Virus (RSV) long terminal repeat (LTR) enhancer, linked to the dexamethasone-inducible mouse mammary tumor virus (MMTV)-LTR promoter, followed by SV40 splicing and polyadenylation sites. pMAMneo also contains

the *E. coli neo* gene for selection of transformants, as well as the β-lactamase gene (encoding a protein which imparts ampicillin-resistance) for propagation in *E. coli*.

Vector pMMTVT7(+) can be generated by modification of pMAMneo to remove the *neo* gene and insert the multiple cloning site and T7 and T3 promoters from pBluescript (Stratagene, La Jolla, CA). Thus, pMMTVT7(+) contains the RSV-LTR enhancer linked to the MMTV-LTR promoter, a T7 bacteriophage RNA polymerase promoter positioned downstream of the MMTV-LTR promoter, a polylinker positioned downstream of the T7 promoter, a T3 bacteriophage RNA polymerase promoter positioned downstream of the T7 promoter, and SV40 splicing and polyadenylation sites positioned downstream of the T3 promoter. The β-lactamase gene (encoding a protein which imparts ampicillin-resistance) from pMAMneo is retained in pMMTVT7(+), although it is incorporated in the reverse orientation relative to the orientation in pMAMneo.

Vector pMMTVT7(-) is identical to pMMTVT7(+) except that the positions of the T7 and T3 promoters are switched, i.e., the T3 promoter in pMMTVT7(-) is located where the T7 promoter is located in pMMTVT7(+), and the T7 promoter in pMMTVT7(-) is located where the T3 promoter is located in pMMTVT7(+). Therefore, vectors pMMTVT7(+) and pMMTVT7(-) contain all of the regulatory elements required for expression of heterologous DNA in a mammalian host cell, wherein the heterologous DNA has been incorporated into the vectors at the polylinker. In addition, because the T7 and T3 promoters are located on either side of the polylinker, these plasmids can be used for synthesis of *in vitro* transcripts of heterologous DNA that has been subcloned into the vectors at the polylinker.

For inducible expression of human NMDA receptor subunit-encoding DNA in a mammalian cell, the DNA can be

inserted into a plasmid such as pMMTVT7(+) or pMMTVT7(-). These plasmids contain the mouse mammary tumor virus (MMTV) promoter for steroid-inducible expression of operatively associated foreign DNA. If the host cell does not express endogenous glucocorticoid receptors required for uptake of glucocorticoids (i.e., inducers of the MMTV promoter) into the cell, it is necessary to additionally transfect the cell with DNA encoding the glucocorticoid receptor (ATCC accession no. 67200). For synthesis of *in vitro* transcripts, full-length human DNA clones encoding human NMDAR1, NMDAR2A, NMDAR2B, NMDAR2C and NMDAR2D can also be subcloned into pIBI24 (International Biotechnologies, Inc., New Haven, CT), pCMV-T7-2, pCMV-T7-3, pMMTVT7(+), pMMTVT7(-), pBluescript (Stratagene, La Jolla, CA) or pGEM7Z (Promega, Madison, WI).

In accordance with another embodiment of the present invention, there are provided cells containing the above-described polynucleic acids (i.e., DNA or mRNA). Such host cells as bacterial, yeast and mammalian cells can be used for replicating DNA and producing NMDA receptor subunit(s). Methods for assessing receptor expression and function are described in PCT Application Nos. PCT/US91/05625 and PCT/US92/11090, and in co-pending U.S. Application Serial Nos. 07/563,751 and 07/812,254. The subject matter of these documents is hereby incorporated by reference herein in their entirety.

Incorporation of cloned DNA into a suitable expression vector, transfection of eukaryotic cells with a plasmid vector or a combination of plasmid vectors, each encoding one or more distinct genes or with linear DNA, and selection of transfected cells are well known in the art (see, e.g., Sambrook et al. (1989) Molecular Cloning: A Laboratory Manual, Second Edition, Cold Spring Harbor Laboratory Press). Heterologous DNA may be introduced into host cells by any method known to those of skill in the

art, such as transfection with a vector encoding the heterologous DNA by $CaPO_4$ precipitation (see, e.g., Wigler et al. (1979) Proc. Natl. Acad. Sci. 76:1373-1376) or lipofectamine (GIBCO BRL #18324-012). Recombinant cells can then be cultured under conditions whereby the subunit(s) encoded by the DNA is (are) expressed. Preferred cells include mammalian cells (e.g., HEK293, CHO, BHKBI and Ltk$^-$ cells, mouse monocyte macrophage P388D1 and J774A-1 cells (available from ATCC, Rockville, MD), and the like), yeast cells (e.g., methylotrophic yeast cells, such as *Pichia pastoris*), bacterial cells (e.g., *Escherichia coli*), and the like.

While the DNA provided herein may be expressed in any eukaryotic cell, including yeast cells (such as, for example, *P. pastoris* (see U.S. Patent Nos. 4,882,279, 4,837,148, 4,929,555 and 4,855,231), *Saccharomyces cerevisiae*, *Candida tropicalis*, *Hansenula polymorpha*, and the like), mammalian expression systems, including commercially available systems and other such systems known to those of skill in the art, for expression of DNA encoding the human NMDA receptor subunits provided herein are presently preferred. *Xenopus* oocytes are preferred for expression of *in vitro* RNA transcripts of the DNA.

In preferred embodiments, human NMDAR subunit-encoding DNA is ligated into a vector, and introduced into suitable host cells to produce transformed cell lines that express a specific human NMDA receptor subtype, or specific combinations of subunits. The resulting cell lines can then be produced in quantity for reproducible quantitative analysis of the effects of known or potential drugs on receptor function. In other embodiments, mRNA may be produced by *in vitro* transcription of DNA encoding each subunit. This mRNA, either from a single subunit clone or from a combination of clones, can then be injected into *Xenopus* oocytes where the mRNA directs the synthesis of the

human receptor subunits, which then form functional receptors. Alternatively, the subunit-encoding DNA can be directly injected into oocytes for expression of functional receptors. The transfected mammalian cells or injected oocytes may then be used in the methods of drug screening provided herein.

Eukaryotic cells in which DNA or RNA may be introduced include any cells that are transfectable by such DNA or RNA or into which such DNA or RNA may be injected. Preferred cells are those that can be transiently or stably transfected and also express the DNA and RNA. Presently most preferred cells are those that can form recombinant or heterologous human NMDA receptors comprising one or more subunits encoded by the heterologous DNA. Such cells may be identified empirically or selected from among those known to be readily transfected or injected.

Exemplary cells for introducing DNA include cells of mammalian origin (e.g., COS cells, mouse L cells, Chinese hamster ovary (CHO) cells, human embryonic kidney (HEK) cells (particularly HEK293 cells that can be frozen in liquid nitrogen and then thawed and regrown; for example, those described in U.S. Patent No. 5,024,939 to Gorman (see, also, Stillman et al. (1985) Mol. Cell. Biol. 5:2051-2060)), African green monkey cells and other such cells known to those of skill in the art), amphibian cells (e.g., *Xenopus laevis* oöcytes), yeast cells (e.g., *Saccharomyces cerevisiae*, *Pichia pastoris*), and the like. Exemplary cells for expressing injected RNA transcripts include *Xenopus laevis* oöcytes. Cells that are preferred for transfection of DNA are known to those of skill in the art or may be empirically identified, and include HEK293 (which are available from ATCC under accession #CRL 1573); Ltk$^-$ cells (which are available from ATCC under accession #CCL1.3); COS-7 cells (which are available from ATCC under accession #CRL 1651); and DG44 cells (dhfr$^-$ CHO cells; see,

e.g., Urlaub et al. (1986) Cell. Molec. Genet. 12: 555). Presently preferred cells include Ltk⁻ cells and DG44 cells.

DNA may be stably incorporated into cells or may be transiently expressed using methods known in the art. Stably transfected mammalian cells may be prepared by transfecting cells with an expression vector having a selectable marker gene (such as, for example, the gene for thymidine kinase, dihydrofolate reductase, neomycin resistance, and the like), and growing the transfected cells under conditions selective for cells expressing the marker gene. To prepare transient transfectants, mammalian cells are transfected with a reporter gene (such as the *E. coli* ß-galactosidase gene) to monitor transfection efficiency. Selectable marker genes are not included in the transient transfections because the transfectants are typically not grown under selective conditions, and are usually analyzed within a few days after transfection.

To produce such stably or transiently transfected cells, the cells should be transfected with a sufficient concentration of subunit-encoding nucleic acids to form human NMDA receptors that contain the human subunits encoded by heterologous DNA. The precise amounts and ratios of DNA encoding the subunits may be empirically determined and optimized for a particular combination of subunits, cells and assay conditions. Recombinant cells that express NMDA receptors containing subunits encoded only by the heterologous DNA or RNA are especially preferred.

Heterologous DNA may be maintained in the cell as an episomal element or may be integrated into chromosomal DNA of the cell. The resulting recombinant cells may then be cultured or subcultured (or passaged, in the case of mammalian cells) from such a culture or a subculture thereof. Methods for transfection, injection and culturing

recombinant cells are known to the skilled artisan. Similarly, the human NMDA receptor subunits may be purified using protein purification methods known to those of skill in the art. For example, antibodies or other ligands that specifically bind to one or more of the subunits may be used for affinity purification and immunoprecipitation of the subunit or human NMDA receptors containing the subunits.

As used herein, heterologous or foreign DNA and RNA are used interchangeably and refer to DNA or RNA that does not occur naturally as part of the genome of the cell in which it is present or to DNA or RNA which is found in a location or locations in the genome that differ from that in which it occurs in nature. Typically, heterologous or foreign DNA and RNA refers to DNA or RNA that is not endogenous to the host cell and has been artificially introduced into the cell. Examples of heterologous DNA include DNA that encodes a human NMDA receptor subunit, DNA that encodes RNA or proteins that mediate or alter expression of endogenous DNA by affecting transcription, translation, or other regulatable biochemical processes, and the like. The cell that expresses heterologous DNA may contain DNA encoding the same or different expression products. Heterologous DNA need not be expressed and may be integrated into the host cell genome or maintained episomally.

Recombinant receptors on recombinant eukaryotic cell surfaces may contain one or more subunits encoded by the DNA or mRNA encoding human NMDA receptor subunits, or may contain a mixture of subunits encoded by the host cell and subunits encoded by heterologous DNA or mRNA. Recombinant receptors may be homomeric or may be a heteromeric combination of multiple subunits. Mixtures of DNA or mRNA encoding receptors from various species, such as rats and humans, may also be introduced into the cells.

Thus, a cell can be prepared that expresses recombinant receptors containing only NMDAR1 subunits, or a combination of any one or more NMDAR1 and any one or more NMDAR2 subunits provided herein. For example, NMDAR1 subunits of the present invention can be co-expressed with NMDAR2A, NMDAR2B, NMDAR2C and/or NMDAR2D receptor subunits. Specific examples of heteromeric combinations of recombinant human NMDAR subunits that have been expressed in *Xenopus* oocytes include NMDAR1 + NMDAR2A, NMDAR1 + NMDAR2B, and NMDAR1 + NMDAR2A + NMDAR2C (see Example 9).

The DNA, mRNA, vectors, receptor subunits, receptor subunit combinations and cells provided herein permit production of selected NMDA receptor subunits and specific combinations thereof, as well as antibodies to said receptor subunits. This provides a means to prepare synthetic or recombinant receptors and receptor subunits that are substantially free of contamination from many other receptor proteins whose presence can interfere with analysis of a single NMDA receptor subtype. The availability of desired receptor subtypes makes it possible to observe the effect of a drug substance on a particular receptor subtype or combination of NMDA receptor subunits, and to thereby perform initial *in vitro* screening of the drug substance in a test system that is specific for humans and specific for a human NMDA receptor subtype or combination of NMDA receptor subunits. The availability of specific antibodies makes it possible to identify the subunit combinations expressed *in vivo*. Such specific combinations can then be employed as preferred targets in drug screening.

The ability to screen drug substances *in vitro* to determine the effect of the drug on specific receptor compositions should permit the development and screening of receptor subtype-specific or disease-specific drugs. Also, testing of single receptor subunits or specific

combinations of various types of receptor subunits with a variety of potential agonists or antagonists provides additional information with respect to the function and activity of the individual subunits and should lead to the identification and design of compounds that are capable of very specific interaction with one or more types of receptor subunits or receptor subtypes. The resulting drugs should exhibit fewer unwanted side effects than drugs identified by screening with cells that express a variety of receptor subtypes.

Further in relation to drug development and therapeutic treatment of various disease states, the availability of DNAs encoding human NMDA receptor subunits enables identification of any alterations in such genes (e.g., mutations) which may correlate with the occurrence of certain disease states. In addition, the creation of animal models of such disease states becomes possible, by specifically introducing such mutations into synthetic DNA sequences which can then be introduced into laboratory animals or *in vitro* assay systems to determine the effects thereof.

In another aspect, the invention comprises functional peptide fragments, and functional combinations thereof, encoded by the DNAs of the invention. Such functional peptide fragments can be produced by those skilled in the art, without undue experimentation, by eliminating some or all of the amino acids in the sequence not essential for the peptide to function as a glutamate receptor. A determination of the amino acids that are essential for glutamate receptor function is made, for example, by systematic digestion of the DNAs encoding the peptides and/or by the introduction of deletions into the DNAs. The modified (e.g., deleted or digested) DNAs are expressed, for example, by transcribing the DNA and then introducing the resulting mRNA into *Xenopus* oocytes, where

translation of the mRNAs will occur. Functional analysis of the proteins thus expressed in the oocytes is accomplished by exposing the oocytes to ligands known to bind to and functionally activate glutamate receptors, and then monitoring the oocytes to see if the expressed fragments form ion channel(s). If ion channel(s) are detected, the fragments are functional as glutamate receptors.

The above-described method can be carried out in the presence of NMDAR1-like receptor subunits alone, or in the presence of combinations of NMDAR1-like and NMDAR2-like receptor subunits. Thus, for example, when the protein being tested is an NMDAR2-like receptor subunit, the additional subunit is preferably an NMDAR1-like subunit.

In accordance with still another embodiment of the present invention, there is provided a method for identifying compounds which bind to human N-methyl-D-aspartate (NMDA) receptor subunit(s), said method comprising employing receptor proteins of the invention in a competitive binding assay. Such an assay can accomodate the rapid screening of a large number of compounds to determine which compounds, if any, are capable of binding to NMDA receptors. Subsequently, more detailed assays can be carried out with those compounds found to bind, to further determine whether such compounds act as modulators, agonists or antagonists of invention receptors.

Another application of the binding assay of the invention is the assay of test samples (e.g., biological fluids) for the presence or absence of receptors of the present invention. Thus, for example, serum from a patient displaying symptoms related to glutamatergic pathway dysfunction can be assayed to determine if the observed symptoms are perhaps caused by over- or under-production of such receptor(s).

The binding assays contemplated by the present invention can be carried out in a variety of ways, as can readily be identified by those of skill in the art. For example, competitive binding assays can be employed, such as radioreceptor assays, and the like.

In accordance with a further embodiment of the present invention, there is provided a bioassay for identifying compounds which modulate the activity of human NMDA receptors of the invention, said bioassay comprising:

(a) exposing cells containing DNA encoding human NMDA receptor subunit(s), wherein said cells express functional NMDA receptors, to at least one compound whose ability to modulate the ion channel activity of said receptors is sought to be determined; and thereafter

(b) monitoring said cells for changes in ion channel activity.

The above-described bioassay enables the identification of agonists and antagonists for human NMDA receptors. According to this method, recombinant NMDA receptors are contacted with an "unknown" or test substance (in the further presence of a known NMDA agonist, when antagonist activity is being tested), the ion channel activity of the known glutamate receptor is monitored subsequent to the contact with the "unknown" or test substance, and those substances which increase or decrease the ion channel response of the known glutamate receptor(s) are identified as functional ligands (i.e., modulators, agonists or antagonists) for human NMDA receptors.

In accordance with a particular embodiment of the present invention, recombinant human NMDA receptor-expressing mammalian cells or oocytes can be contacted with a test compound, and the modulating effect(s) thereof can then be evaluated by comparing the

NMDA receptor-mediated response in the presence and absence of test compound, or by comparing the response of test cells, or control cells (i.e., cells that do not express NMDA receptors), to the presence of the compound.

As used herein, a compound or signal that "modulates the activity of an NMDA receptor" refers to a compound or signal that alters the activity of NMDA receptors so that activity of the NMDA receptor is different in the presence of the compound or signal than in the absence of the compound or signal. In particular, such compounds or signals include agonists and antagonists. The term agonist refers to a substance or signal, such as NMDA, that activates receptor function; and the term antagonist refers to a substance that interferes with receptor function. Typically, the effect of an antagonist is observed as a blocking of activation by an agonist. Antagonists include competitive and non-competitive antagonists. A competitive antagonist (or competitive blocker) interacts with or near the site specific for the agonist (e.g., ligand or neurotransmitter). A non-competitive antagonist or blocker inactivates the functioning of the receptor by interacting with a site other than the site that interacts with the agonist.

As understood by those of skill in the art, assay methods for identifying compounds that modulate human NMDA receptor activity (e.g., agonists and antagonists) generally require comparison to a control. One type of a "control" cell or "control" culture is a cell or culture that is treated substantially the same as the cell or culture exposed to the test compound, except the control culture is not exposed to test compound. For example, in methods that use voltage clamp electrophysiological procedures, the same cell can be tested in the presence and absence of test compound, by merely changing the external solution bathing the cell. Another type of "control" cell

or "control" culture may be a cell or a culture of cells which is identical to the transfected cells, except the cells employed for the control culture do not express functional human NMDA receptor subunits. In this situation, the response of test cell to test compound is compared to the response (or lack of response) of receptor-negative (control) cell to test compound, when cells or cultures of each type of cell are exposed to substantially the same reaction conditions in the presence of compound being assayed.

In accordance with yet another embodiment of the present invention, the ion channel activity of human N-methyl-D-aspartate (NMDA) receptors can be modulated by contacting such receptors with an effective amount of at least one compound identified by the above-described bioassay.

In accordance with yet another embodiment of the present invention, there are provided antibodies generated against the above-described receptor proteins. Such antibodies can be employed for studying receptor tissue localization, subunit composition, structure of functional domains, as well as in diagnostic applications, therapeutic applications, and the like. Preferably, for therapeutic applications, the antibodies employed will be monoclonal antibodies.

The above-described antibodies can be prepared employing standard techniques, as are well known to those of skill in the art, using the invention receptor proteins or portions thereof as antigens for antibody production. Both anti-peptide and anti-fusion protein antibodies can be used [see, for example, Bahouth et al. (1991) Trends Pharmacol Sci. vol. 12:338-343; Current Protocols in Molecular Biology (Ausubel et al., eds.) John Wiley and Sons, New York (1989)]. Factors to consider in selecting

portions of the NMDAR subunits for use as immunogen (as either a synthetic peptide or a recombinantly produced bacterial fusion protein) include antigenicity, accessibility (i.e., extracellular and cytoplasmic domains), uniqueness to the particular subunit, etc.

The availability of subunit-specific antibodies makes possible the application of the technique of immunohistochemistry to monitor the distribution and expression density of various subunits (e.g., in normal vs diseased brain tissue). Such antibodies could also be employed for diagnostic and therapeutic applications.

In accordance with still another embodiment of the present invention, there are provided methods for modulating the ion channel activity of receptor(s) of the invention by contacting said receptor(s) with an effective amount of the above-described antibodies.

The antibodies of the invention can be administered to a subject employing standard methods, such as, for example, by intraperitoneal, intramuscular, intravenous, or subcutaneous injection, implant or transdermal modes of administration, and the like. One of skill in the art can readily determine dose forms, treatment regiments, etc, depending on the mode of administration employed.

The invention will now be described in greater detail by reference to the following non-limiting examples.

Example 1

Isolation of DNA encoding human NMDA receptor NMDAR1 subunits

A. cDNA Library Screening

RNA isolated from human hippocampus tissue was used as a template for the synthesis of oligo dT-primed and randomly primed, single-stranded cDNA according to standard procedures [see, for example, Maniatis et al. (1982) Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY]. The single-stranded cDNA was converted to double-stranded cDNA, and *Eco*RI/*Sna*BI/*Xho*I adaptors were added to the ends thereof. The cDNAs were separated by size using agarose gel electrophoresis, and those that were >2.0 kb were ligated into *Eco*RI-digested λgt10 bacteriophage vectors. The resulting cDNA library was amplified by replication of each clone through limited infection of a bacterial host, and stored at -70°C.

The amplified hippocampus oligo dT-primed cDNA library was later retrieved from storage and 1 x 10^6 recombinants were screened for hybridization to oligonucleotides corresponding to nucleotides 96-128 (SE7) and nucleotides 2576-2609 (SE8) of the rat NMDAR1A receptor cDNA (see Moriyoshi *et al.* (1991) *Nature* 354:31). Hybridization was performed at 42°C in 6X SSPE, 5X Denhart's solution, 10% formamide, 0.2% SDS and 200 μg/ml herring sperm DNA. Washes were performed in 1X SSPE and 0.2% SDS at 50°C. Hybridizing clones (e.g. NMDA1-3) were identified. These clones hybridized to SE8 but not to SE7.

A randomly primed primary human hippocampus cDNA library (~2 x 10^5 recombinants prepared by selecting only cDNAs >2.0 kb for inclusion in the library) was screened under the same conditions for hybridization to

oligonucleotide SE8 and an oligonucleotide corresponding to nucleotides 129-141 of the rat NMDAR1A receptor cDNA (SE11). Five hybridizing clones, which hybridized to SE8 and not to SE11, were identified: NMDA5-7 and NMDA10-11.

B. Characterization of Clones

The clones were plaque purified and characterized by restriction enzyme mapping and DNA sequence analysis of the inserts. One of the clones, NMDA11 (see Sequence ID No. 1B for a description of a portion of NMDA11), is a full-length cDNA (i.e., it contains translation initiation and termination codons) encoding a complete NMDAR1 subunit. The remaining clones are partial cDNAs. Clones NMDA2, NMDA3 (see Sequence ID No. 1D), NMDA5, NMDA6, NMDA7 (see Sequence ID No. 1C), and NMDA10 (see Sequence ID No. 1A for a description of a portion of NMDA10) contain a translation termination codon but lack nucleotides at the 5' end of the coding sequence.

Characterization of the clones revealed that the isolated cDNAs correspond to different alternatively spliced forms of the human NMDAR1 subunit transcript. The four types of alternate splicing represented by the clones are depicted schematically in Figure 1. Clone NMDA10 (which lacks 5' untranslated sequences as well as 60 nucleotides of the 5' end of the coding sequence) is used as a reference to which the other variants are compared. Clone NMDA11 lacks 363 nucleotides (in the 3' portion of the clone) that are present in NMDA10. This 363-nucleotide deletion does not disrupt the reading frame of the transcript; however, it results in a different termination codon. The last 69 nucleotides of the coding sequence of NMDA11 correspond to 3' untranslated sequence of clone NMDA10 (i.e., nucleotides 3325-3393 of Sequence ID No. 1). Clone NMDA7 lacks the same 363-nucleotide sequence that is deleted from NMDA11; however, NMDA7 further lacks 204

nucleotides at the 5' end that are present in NMDA10 and NMDA11. This 204-nucleotide deletion also does not disrupt the reading frame of the transcript. Additionally, NMDA7 contains a 63-nucleotide in-frame insertion at the 5' end relative to NMDA10 and NMDA11. The last 69 base pairs of the coding sequence of NMDA7 correspond to 3' untranslated sequence of NMDA10 i.e., nucleotides 3325-3393 of Sequence ID No. 1). Clone NMDA3 lacks 1087 base pairs at the 3' end that are present in NMDA10. This 1087-base pair deletion does not disrupt the reading frame of the transcript; however it results in a different termination codon. The last 231 base pairs of the coding sequence of NMDA3 correspond to 3' untranslated sequence of clone NMDA10 (i.e., nucleotides 4049-4279 in Sequence ID No. 1).

Example 2

Preparation of full-length NMDAR1 subunit cDNA constructs

Portions of clones NMDA10, NMDA11, NMDA7 and NMDA3 were ligated together to construct full-length cDNAs encoding variants of the NMDA receptor NMDAR1 subunit. The full-length NMDAR1 subunit cDNAs were incorporated into vector pcDNA1 (Invitrogen, San Diego, CA) for use in expressing the receptor subunits in mammalian host cells and for use in generating *in vitro* transcripts of the DNAs to be expressed in *Xenopus* oocytes.

Vector pcDNA1 is a pUC19-based plasmid that contains the following elements in the 5'-to-3' order: the cytomegalovirus (CMV) immediate early gene promoter/enhancer, the bacteriophage T7 RNA polymerase promoter, a polylinker, the bacteriophage SP6 RNA polymerase promoter, SV40 RNA processing (i.e., splice donor/acceptor) signals, SV40 polyadenylation signal, and the ColE1 origin and supF suppressor tRNA to permit maintenance of the vector in *Escherichia coli* strains with the P3 episome. This vector thus contains all the

regulatory elements required for expression of heterologous DNA in a mammalian host cell, wherein the heterologous DNA has been incorporated into the vector at the polylinker. In addition, because the T7 and SP6 promoters are located on either side of the polylinker, this plasmid can be used for synthesis of *in vitro* transcripts of heterologous DNA that has been sublconed into the vector at the polylinker.

A. NMDAR1A

Full-length construct NMDAR1A was prepared by ligation of a 5' portion of NMDA11 (beginning 5' of the translation initiation codon and extending to the *Hin*dIII site in the middle of the clone) and a 3' portion of NMDA10 (beginning at the *Hin*dIII site in the middle of the clone and extending 3' of the translation termination codon) as depicted in Figure 2. The two DNA fragments were joined in mammalian expression vector pcDNA1.

Initially, the strategy for generating the NMDAR1 construct involved a first step of separately subcloning the entire 4.0 kb *Eco*RI insert fragment of NMDA10 and the entire 4.0 kb *Sna*BI insert fragment of NMDA11 into pcDNA1; however, two attempts employing this cloning strategy were unsuccessful. It appeared that there may have been selection against *E. coli* hosts retaining the complete insert fragments since the surviving recombinant *E. coli* that were analyzed contained incomplete insert cDNAs from which nucleotides had been deleted. Therefore, it was necessary to prepare the full-length NMDAR1A construct in several steps by subcloning and combining various fragments of NMDA10 and NMDA11 in pcDNA1 as follows (see Figure 3 for locations of restriction enzyme sites).

Clone NMDA10 was digested with *Bgl*II and *Eco*RI and the ~3.3 kb fragment containing nucleotides 1020-4298 of Sequence ID No. 1 was isolated and subcloned into

*Bam*HI/*Eco*RI-digested pcDNA1. The resulting plasmid was digested with *Hin*dIII and *Nhe*I and the fragment containing nucleotides 2137-4298 of Sequence ID No. 1 plus a portion of pcDNA1 was isolated.

Clone NMDA11 was digested with *Eco*RI and *Hin*dIII and the ~2.1 kb fragment containing nucleotides 1-2136 of Sequence ID No. 1 was isolated and subcloned into *Eco*RI/*Hin*dIII-digested modified pcDNA1 (modified by deletion of the *Hin*dIII site located 5' of the *Eco*RI site in the polylinker and addition of a *Hin*dIII site into the polylinker at a position 3' of the *Eco*RI site). The resulting plasmid was digested with *Nhe*I and *Hin*dIII and the fragment containing nucleotides 1-2136 of Sequence ID No. 1 plus a portion of modified pcDNA1 was isolated. This *Nhe*I/*Hin*dIII fragment was then ligated to the *Hin*dIII/*Nhe*I fragment containing nucleotides 2137-4298 of Sequence ID No. 1 to generate the full-length construct NMDAR1A (see Figure 2). The ligation mix was used to transform *E. coli* strain MC1061/P3. Because the *Nhe*I site in pcDNA1 occurs within the supF selection gene, only *E. coli* containing the correctly ligated, complete NMDAR1A plasmid (which has the complete, functional selection gene) were able to survive the selection process. This fragment subcloning strategy enabled selection of the desired correct NMDAR1A-containing *E. coli* host cells, even though the total number of such recombinant host cells was small.

In summary, construct NMDAR1A contains 261 base pairs of 5' untranslated sequence from NMDAR11 (nucleotides 1-261 of Sequence ID No. 1) and a complete coding sequence (nucleotides 262-3078 of Sequence ID No.1) for the NMDAR1A variant of the NMDAR1 subunit as well as 1220 base pairs of 3' untranslated sequence (nucleotides 3079-4298 of Sequence ID No. 1). The NMDAR1A-encoding sequence is operatively

linked to the regulatory elements in pcDNA1 for expression in mammalian cells.

B. NMDAR1-Δ363

Full-length construct NMDAR1-Δ363 was prepared by ligation of a 5' portion of NMDA11 (beginning 5' of the translation initiation codon and extending to the *Hin*dIII site in the middle of the clone, i.e., nucleotides 1-2136 in Sequence ID No. 1) and a 3' portion of NMDA11 (beginning at the *Hin*dIII site in the middle of the clone and extending 3' of the translation termination codon, i.e., nucleotides 2137-2961 and 3325-4298 of Sequence ID No. 1). As described above, due to the difficulty in directly subcloning the entire 4.0 kb *Sna*BI NMDA11 insert into pcDNA1, it was necessary to generate the construct by ligating two fragments of the NMDA11 insert into pcDNA1 as follows (see Figure 3 for locations of restriction enzyme sites).

To obtain the 5' NMDA11 fragment, clone NMDA11 was digested with *Eco*RI and *Hin*dIII and the ~2.2 kb fragment containing nucleotides 1-2136 of Sequence ID No. 1 was isolated and subcloned into *Eco*RI/*Hin*dIII-digested modified pcDNA1 (modified as described above). The resulting plasmid was digested with *Nhe*I and *Hin*dIII and the fragment containing nucleotides 1-2136 of Sequence ID No. 1 plus a portion of modified pcDNA1 was isolated.

To obtain the 3' NMDA11 fragment, clone NMDA11 was digested with *Bgl*II and *Eco*RI and the 3.0 kb fragment containing nucleotides 1020-2961 and 3325-4298 of Sequence ID No. 1 was isolated and subcloned into *Bam*HI/*Eco*RI-digested pcDNA1. The resulting plasmid was digested with *Hin*dIII and *Nhe*I and the fragment containing nucleotides 2137-2961 and 3325-4298 of Sequence ID No. 1 plus a portion of pcDNA1 was isolated. This *Hin*dIII/*Nhe*I fragment was

then ligated to the *Nhe*I/*Hind*III fragment containing nucleotides 1-2136 of Sequence ID No. 1 to generate NMDAR1-Δ363.

In summary, construct NMDAR1-Δ363 contains 261 base pairs of 5' untranslated sequence (nucleotides 1-261 of Sequence ID No. 1) and a complete coding sequence for the NMDAR1-Δ363 variant NMDAR1 subunit (nucleotides 262-2961 and 3325-3393 of Sequence ID No. 1) as well as 905 base pairs of 3' untranslated sequence (nucleotides 3394-4298 of Sequence ID No. 1). Thus, NMDAR1-Δ363 differs from NMDAR1 in that it lacks 363 nucleotides (nucleotides 2962-3324 of Sequence ID No. 1) that comprise the last 117 nucleotides of the coding sequence and the first 246 nucleotides of the 3' untranslated sequence of NMDAR1. The NMDAR1-Δ363 subunit variant-encoding sequence is operatively linked to the regulatory elements in pcDNA1 for expression in mammalian cells.

C. NMDAR1-Δ1087

Full-length construct NMDAR1-Δ1087 was prepared by replacing the 3' end of the NMDAR1 variant-encoding insert of NMDAR1-Δ363 with a fragment from the 3' end of clone NMDA3 (see Figure 2). Plasmid NMDAR1-Δ363 was partially digested with *Pst*I and completely digested with *Xba*I. There is a *Pst*I site ~112 nucleotides upstream of the location of the 363-nucleotide deletion in NMDAR1-Δ363 and an *Xba*I site in the polylinker located downstream of the 3' untranslated sequence of NMDAR1-Δ363 (see Figure 3). Thus, *Pst*I/*Xba*I digestion of NMDAR1-Δ363 results in removal of a fragment containing nucleotides 2850-2961 and 3325-4298 of Sequence ID No. 1 from the vector. The larger fragment was isolated from the digest.

The insert of clone NMDA3 was cloned into the EcoRI restriction site(s) of pGEM (Promega, Madison, WI);

and the resulting plasmid was digested with *Pst*I and *Xba*I. The smaller fragment containing nucleotides 2850-2961 and 4049-4298 of Sequence ID No. 1 was isolated and ligated to the larger fragment from the *Pst*I/*Xba*I digest of NMDAR1-Δ363. The resulting construct was designated NMDAR1-Δ1087.

In summary, NMDAR1-Δ1087 contains 261 base pairs of 5' untranslated sequence (nucleotides 1-261 in Sequence ID No. 1), the complete coding sequence for the NMDAR1-Δ1087 variant NMDAR1 subunit (nucleotides 262-2961 and 4049-4279 of Sequence ID No. 1) and 19 base pairs of 3' untranslated sequence (nucleotides 4280-4298 of Sequence ID No. 1). Thus, NMDAR1-Δ1087 differs from NMDAR1 in that it lacks 1087 nucleotides (nucleotides 2962-4048 of Sequence ID No. 1) that comprise the last 117 nucleotides of the coding sequence and the first 970 nucleotides of the 3' untranslated sequence of NMDAR1. The NMDAR1-Δ1087 subunit variant-encoding sequence is operatively linked to the regulatory elements in pcDNA1 for expression in mammalian cells.

D. NMDAR1-I63-Δ204

Full-length construct NMDAR1-I63-Δ204 was prepared by replacing a 1399-nucleotide fragment of construct NMDAR1A (i.e, nucleotides 738-2136 of Sequence ID No. 1) with the *Pvu*II-*Hin*dIII fragment of NMDA7 (i.e., nucleotides 738-831 of sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3 and nucleotides 832-984 and 1189-2136 of Sequence ID No. 1), as depicted in Figure 2. Because there are multiple *Pvu*II sites in the NMDAR1 construct, a several-step process was required for construction of NMDAR1-I63-Δ204 as follows (see Figure 3 for the location of restriction enzyme sites).

The ~2.2-kb *Eco*RI-*Hin*dIII fragment isolated from construct NMDAR1A and containing nucleotides 1-2136 of

Sequence ID No. 1 was ligated with modified pcDNA1 (modified as described in Example 2A) that had been digested with *Eco*RI and *Hin*dIII. The resulting plasmid was digested with *Avr*II and self-ligated to remove two *Pvu*II sites from a portion of the plasmid contributed by pcDNA1. The plasmid was then partially digested with *Pvu*II and completely digested with *Hin*dIII. The digest was ligated with a 1258-nucleotide *Pvu*II-*Hin*dIII fragment isolated from clone NMDA7. The resulting plasmid, designated NMDAR1-I63-Δ204-5', was digested with *Bam*HI and *Hin*dIII and the ~2-kb fragment containing nucleotides 1-831 of Sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3 and nucleotides 832-984 and 1189-2136 of Sequence ID No. 1 was isolated and ligated to *Bam*HI/*Hin*dIII-digested NMDAR1 to generate NMDAR1-I63-Δ204.

NMDAR1-I63-Δ204 contains 261 base pairs of 5' untranslated sequence (nucleotides 1-261 in Sequence ID No. 1), the complete coding sequence for the NMDAR1-I63-Δ204 variant NMDAR1 subunit (nucleotides 262-831 of Sequence ID No. 1 plus nucleotides 1-63 of Sequence ID No. 3 and nucleotides 832-984 and 1189-3078 of Sequence ID No. 1) and 1220 base pairs of 3' untranslated sequence (nucleotides 3079-4298 of Sequence ID No. 1). Thus NMDAR1-I63-Δ204 differs from NMDAR1 in that it contains 63 nucleotides that are not present in NMDAR1 (nucleotides 1-63 of Sequence ID No. 3) located between nt 831 and 832 of Sequence ID No. 1. Further, NMDAR1-I63-Δ204 lacks 204 nucleotides that are present in NMDAR1 (nucleotides 985-1188 of Sequence ID No. 1). The NMDAR1-I63-Δ204 subunit variant-encoding sequence is operatively linked to the regulatory elements in pcDNA1 for expression in mammalian cells.

E. NMDAR1-I63

Full-length construct NMDAR1-I63 can be described as NMDAR1 in which a 173-bp fragment (nucleotides 738-910 of Sequence ID No. 1) is replaced with the 236-bp *Pvu*II-*Sma*I fragment of NMDA7 (nucleotides 738-831 of Sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3 and nucleotides 832-910 of Sequence ID No. 1). Because there are multiple *Pvu*II sites in the NMDAR1 construct, a several-step process was required for construction of NMDAR1-I63 as follows. Plasmid NMDAR1-I63-Δ204-5' was partially digested with *Sma*I and completely digested with *Hin*dIII. The larger vector fragment was ligated with the 1226-bp *Sma*I/*Hin*dIII fragment isolated from NMDA11 (nucleotides 911-2136 of Sequence ID No. 1). The resulting vector was digested with *Bam*HI and *Hin*dIII and the ~2.2-kb fragment containing nucleotides 1-831 of Sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3 and nucleotides 832-2136 of Sequence ID No. 1 was isolated and ligated to *Bam*HI/*Hin*dIII-digested NMDAR1 to generate NMDAR1-I63.

NMDAR1-I63 contains 261 base pairs of 5' untranslated sequence (nucleotides 1-261 in Sequence ID No. 1), the complete coding sequence for the NMDAR1-I63 variant NMDAR1 subunit (nucleotides 262-831 of Sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3 and nucleotides 832-3078 of Sequence ID No. 1) and 1220 nucleotides of 3' untranslated sequence (nucleotides 3079-4298 of Sequence ID No. 1). Thus, NMDAR1-I63 differs from NMDAR1 in that it contains 63 nucleotides that are not present in NMDAR1 (nucleotides 1-63 of Sequence ID No. 3), located between nucleotides 831 and 832 of Sequence ID No. 1. The NMDAR1-I63 subunit variant-encoding sequence is operatively linked to the regulatory elements in pcDNA1 for expression in mammalian cells.

F. NMDAR1-I63-Δ204-Δ363

Full-length construct NMDAR1-I63-Δ204-Δ363 was prepared by replacing the 2861 nucleotide fragment from construct NMDAR1-I63-Δ204 (ie, nucleotides 1438-4298 Sequence ID. No. 1) with the *Kpn*I-*Xba*I (polylinker site) fragment of NMDAR1-Δ363 (ie, nucleotides 1438-2961 and 3325-4298 of Sequence ID No. 1) as depicted in Figure 2. The NMDAR1-I63-Δ204 was completely digested with *Xba*I then partially digested with *Kpn*I due to the presence of two additional *Kpn*I sites in the vector sequence. The resulting 5' NMDAR1-I63-Δ204 fragment, which includes the pcDNAI vector sequences, was ligated with the 3' *Kpn*I-*Xba*I fragment from NMDAR1-Δ363 to generate NMDAR1-I63-Δ204-Δ363.

In summary, construct NMDAR1-I63-Δ204-Δ363 contains 261 base pairs of 5' untranslated sequence (nucleotides 1-261 in Sequence ID No. 1), the complete coding sequence for the NMDAR1-I63-Δ204-Δ363 variant NMDAR1A subunit (nucleotides 262-831 of Sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3, plus nucleotides 832-984, 1189-2961 and 3325-3393 of Sequence ID No. 1) as well as 905 base pairs of 3' untranslated sequence (nucleotides 3394-4298 of Sequence ID. No. 1). Thus, NMDAR1-I63-Δ204-Δ363 differs from NMDAR1A in that it contains 63 nucleotides that are not present in NMDAR1A (nucleotides 1-63 of Sequence ID No. 3) located between nucleotides 831 and 832 of Sequence ID No. 1. Further, NMDAR1-I63-Δ204-Δ363 lacks 204 nucleotides that are present in NMDAR1A (nucleotides 985-1188 of Sequence ID No. 1) and 363 nucleotides that are present in NMDAR1A (nucleotides 2962-3324 of Sequence ID No. 1) that comprise the last 117 nucleotides of the coding sequence and the first 246 nucleotides of the 3' untranslated sequence of NMDAR1A. The NMDAR1-I63-Δ204-Δ363 subunit variant encoding sequence is operatively linked to the regulatory elements in pcDNAI for expression in mammalian cells.

G. NMDAR1-I63-Δ204-Δ1087

Full-length construct NMDAR1-I63-Δ204-Δ1087 was prepared by replacing the 2861 nucleotide fragment from construct NMDAR1-I63-Δ204 (ie, nucleotides 1438-4298 Sequence ID. N. 1) with the KpnI-XbaI (polylinker site) fragment of NMDAR1-Δ1087 (ie, nucleotides 1438-2961 and 4049-4298 of Sequence ID No. 1) as depicted in Figure 2. The NMDAR1-I63-Δ204 was completely digested with XbaI then partially digested with KpnI due to the presence of two additional KpnI sites in the vector sequence. The resulting 5' NMDAR1-I63-Δ204 fragment, which includes the pcDNAI vector sequences, was ligated with the 3' KpnI-XbaI fragment from NMDAR1-Δ1087 to generate NMDAR1-I63-Δ204-Δ1087.

In summary, construct NMDAR1-I63-Δ204-Δ1087 contains 261 base pairs of 5' untranslated sequence (nucleotides 1-261 in Sequence ID No. 1), the complete coding sequence for the NMDAR1-I63-Δ204-Δ363 variant NMDAR1A subunit (nucleotides 262-831 of Sequence ID No. 1, plus nucleotides 1-63 of Sequence ID No. 3, plus nucleotides 832-984, 1189-2961 and 4280-4298 of Sequence ID No. 1) as well as 19 base pairs of 3' untranslated sequence (nucleotides 4280-4298 of Sequence ID. No. 1). Thus, NMDAR1-I63-Δ204-Δ1087 differs from NMDAR1A in that it contains 63 nucleotides that are not present in NMDAR1A (nucleotides 1-63 of Sequence ID No. 3) located between nucleotides 831 and 832 of Sequence ID No. 1. Further, NMDAR1-I63-Δ204-Δ1087 lacks 204 nucleotides that are present in NMDAR1A (nucleotides 985-1188 of Sequence ID No. 1) and 1087 nucleotides that are present in NMDAR1A (nucleotides 2962-4048 of Sequence ID No. 1) that comprise the last 117 nucleotides of the coding sequence and the first 970 nucleotides of the 3' untranslated sequence of NMDAR1A. The NMDAR1-I63-Δ204-Δ1087 subunit variant

encoding sequence is operatively linked to the regulatory elements in pcDNAI for expression in mammalian cells.

H. Additional Constructs Containing Full-Length cDNAs Encoding Variants of the NMDAR1 Subunit

Additional full-length cDNAs encoding further possible NMDAR1 variants can be constructed using methods similar to those described in Examples 2A-G above. Specifically, the following constructs can be prepared by ligating portions of clones NMDA11, NMDA10, NMDA7 and NMDA3 as depicted in Figure 2:

NMDAR1-Δ204	(Sequence ID No. 1J)
NMDAR1-Δ204-Δ363	(Sequence ID No. 1K)
NMDAR1-I63-Δ363	(Sequence ID No. 1M)
NMDAR1-I63-Δ1087	(Sequence ID No. 1N)
NMDAR1-Δ204-Δ1087	(Sequence ID No. 1L)

The full-length cDNAs can also be incorporated into mammalian expression vectors such as pcDNA1, as described in Examples 2A-G.

Several methods can be employed to determine which NMDAR1 subunit variants are actually expressed in various human tissues. For example, oligonucleotides specific for the nucleotide sequences located 5' and 3' of the insertions and deletions of the NMDAR1 transcripts described herein can be used to prime nucleic acid amplifications of RNA isolated from various tissues and/or cDNA libraries prepared from various tissues. The presence or absence of amplification products and the sizes of the products indicate which variants are expressed in the tissues. The products can also be characterized more thoroughly by DNA sequence analysis.

RNase protection assays can also be used to determine which variant transcripts are expressed in various tissues. These assays are a sensitive method for detecting and quantitating an RNA species in a complex mixture of total cellular RNA. A portion of the NMDAR1 subunit variant DNA is labeled and hybridized with cellular RNA. If complementary mRNA is present in the cellular RNA, a DNA-RNA hybrid results. The RNA sample is then treated with RNase, which degrades single-stranded RNA. Any RNA-DNA hybrids are protected from RNase degradation and can be visualed by gel electrophoresis and autoradiography.

Further information on possible splice variants of the NMDAR1 primary transcript can be obtained by isolation of genomic clones containing NMDAR1 subunit-encoding sequences (for example, by hybridization to the human NMDAR1 subunit cDNAs disclosed herein) and subsequent characterization of the resulting clones.

Example 3

Isolation of DNA Encoding Human NMDA Receptor NMDAR2C Subunits

Degenerate oligonucleotides were synthesized based on two conserved regions of rat NMDAR2A, NMDAR2B and NMDAR2C DNAs that encode the putative first and fourth transmembrane domains. In rat NMDAR2A DNA, these regions are encoded by nucleotides 1669-1692 (oligo SE74) and 2437-2465 (olig SE75), respectively. [see Monyer *et al.* (1992) *Science 256*:1217-1221]. These oligonucleotides were used to prime nucleic acid amplification of cDNAs prepared from RNA isolated from human hippocampus, cerebellum, and orbitofrontal tissue. Two products, a 795-bp and a 640-bp fragment, were detected when the reaction mixture was analyzed by gel electrophoresis and ethidium bromide staining. The 795-bp fragment amplified from the cerebellum cDNA was subcloned into PCR1000 (Invitrogen, San

Diego, CA) and characterized by DNA sequence analysis, which revealed that it is ~86% similar to the rat NMDAR2A DNA sequence, ~78% similar to the rat NMDAR2B DNA sequence, and ~74% similar to the rat NMDAR2C DNA sequence. Thus, this plasmid was named pcrNMDAR2A.

The 795-bp insert from pcrNMDAR2A was used to screen 1 x 10^6 recombinants of a human hippocampus cDNA library (prepared by using random primers to synthesize cDNAs from hippocampus tissue and selecting fragments >2.0 kb for insertion into λgt10 vectors) and a human cerebellum cDNA library (random-primed library size-selected for fragments >2.8 kb in λgt10). Hybridization was performed in 5X SSPE, 5X Denhart's solution, 50% deionized formamide, 0.2% SDS, 200 μg/ml sonicated, denatured herring sperm DNA at 42°C. Washes were performed in 1X SSPE, 0.2% SDS at 55°C. The probe hybridized to 11 plaques from the hippocampus library and 8 plaques from the cerebellum library.

DNA sequence analysis and/or restriction enzyme mapping of 15 of the hybridizing plaques that were purified surprisingly revealed that they were more similar to rat NMDAR2C DNA than to rat NMDAR2A DNA. All of the clones were partial cDNAs (i.e., they lacked a translation initiation and/or termination codon) and were designated as NMDAR2C cDNAs. Comparison of the clones revealed that the human NMDAR2C subunit transcript is differentially processed.

Clones NMDA26, NMDA24, NMDA22 and NMDA21 (see Figure 4) represent four basic clones that were identified, all of which are believed to be splice variants. Clone NMDA26 (Sequence ID No. 5D) is used as a reference to which the other variants can be compared. Clone NMDA24 (Sequence ID No. 5C) contains a 24-bp sequence (see Sequence ID No. 7) that is not present in NMDA26. Clone NMDA22 (Sequence

ID No. 5B) lacks 15 bp that are present in NMDA26, and clone NMDA21 (Sequence ID No. 5A) lacks 51 bp that are present in NMDA26. Clones NMDA22 and NMDA24 both contain an 11-bp sequence (Sequence ID No. 9) that is not present in NMDA26 (between nucleotides 1116-1117 of Sequence ID No. 5). Introduction of this sequence into these clones (between nucleotides 1116-1117 of Sequence ID No. 5) disrupts the reading frame of the transcript and introduces a premature translation termination (i.e., STOP) codon into the transcript.

Clones NMDA26 and NMDA27 (see Figure 4) are partial NMDAR2C cDNAs that contain 5' untranslated sequence, a translation initiation codon and some of the coding sequence. Clone NMDA26 contains 188 base pairs of 5' untranslated sequence whereas clone NMDA27 contains ~1.1 kb of 5' untranslated sequence. The sequences of the 5' untranslated regions of these two clones are identical for the first 15 nucleotides proceeding 5' of the translation initiation codon. However, beginning with the 16th nucleotide 5' of the translation initiation codon, the sequences of the two clones diverge (compare nucleotides 116-191 of Sequence ID No. 5 to nucleotides 1 - 74 of Sequence ID No. 12).

Example 4

Preparation of Full-length NMDAR2C Subunit cDNA Constructs

Portions of the partial NMDAR2C clones can be ligated in a variety of ways to generate constructs encoding full-length NMDAR2C subunit variants. The 5' end of each NMDAR2C cDNA can be contributed by NMDA26, whereas the 3' ends of the constructs are contributed by various combinations of clones NMDA21, NMDA22, and NMDA24. Figure 5 depicts full-length NMDAR2C constructs and indicates the portions of the different clones that contribute to each construct.

For example, full-length constructs can be prepared using methods such as those described in Example 2 for preparing NMDAR1 constructs. Thus, clone inserts are transferred into a vector (e.g., pcDNA1) for ease of manipulation and then desired portions of the cDNAs are isolated by restriction enzyme digestion of the vectors. This can require several steps and/or partial digests if, for example, there are no unique restriction enzyme sites surrounding the desired portions of the cDNAs. The desired cDNA fragments are then ligated and incorporated into an expression plasmid such as pcDNA1 or pCMV-T7-2.

Plasmid pCMV-T7-2 (see Figure 6) is a pUC19-based vector that contains a cytomegalovirus (CMV) promoter/enhancer, SV40 splice donor/splice acceptor sites located immediately downstream of the promoter, a T7 bacteriophage RNA polymerase promoter positioned downstream of the SV40 splice sites, an SV40 polyadenylation signal downstream of the T7 promoter, and a polylinker between the T7 promoter and the polyadenylation signal. This vector thus contains all the regulatory elements required for expression of heterologous DNA in a mammalian host cell, wherein the heterologous DNA has been incorporated into the vector at the polylinker. In addition, because the T7 promoter is located just upstream of the polylinker, this plasmid can be used for synthesis of *in vitro* transcripts of heterologous DNA that has been subcloned into the vector at the polylinker. Plasmid pCMV-T7-3, also depicted in Figure 6, is identical to pCMV-T7-2 except that the order of the restriction enzyme sites in the polylinker is reversed. This plasmid can also be used for heterologous expression of NMDAR subunit DNA.

Construct pcDNA1-26-NotI-24-5'UT contains 188 base pairs of 5' untranslated sequence (nucleotides 1-188 of Sequence ID No. 5), the complete coding sequence of the first variant of the human NMDAR2C subunit (nucleotides

189-3899 of Sequence ID No. 5) and ~440 base pairs of 3' untranslated sequence (nucleotides 3900-4340 of Sequence ID No. 5). The NMDAR2C cDNA is contained within the polylinker of expression vector pcDNA1 for expression.

Construct pCMV-26-NotI-24 (Sequence ID No. 5) contains 49 base pairs of 5' untranslated sequence (nucleotides 140-188 of Sequence ID No. 5), the complete coding sequence of a first variant of the human NMDAR2C subunit (nucleotides 189-3899 of Sequence ID No. 5) and ~440 base pairs of 3' untranslated sequence (nuceotides 3900-4340 of Sequence ID No. 5). The NMDAR2C cDNA is contained within the polylinker of expression vector pCMV-T7-2 for expression.

Construct pCMV-26-ScaI-24 (Sequence ID No. 5E) is identical to pCMV-26-NotI-24, except it contains 24-base pairs (Sequence ID No. 7) inserted between nucleotides 2350 and 2351 of Sequence ID No. 5.

Construct pCMV-26-ScaI-22 (Sequence ID No. 5F) is identical to pCMV-26-NotI-24, except that it lacks 15-base pairs (nucleotides 1960-1974 of Sequence ID No. 5).

Construct pCMV-26-ScaI-21-NotI-24 (Sequence ID No. 5G) is identical to pCMV-26-NotI-24, except that it lacks 51-base pairs (nucleotides 2351-2401 of Sequence ID No. 5).

Construct NMDAR2C-Δ15-I24 (Sequence ID No. 5H) is identical to pCMV-26-NotI-24, except that it lacks 15-base pairs (i.e., nucleotides 1960-1974 of Sequence ID No. 5) and includes a 24-base pair sequence (i.e., Sequence ID No. 7; inserted between nucleotides 2350 and 2351 of Sequence ID No. 5).

Construct NMDAR2C-Δ15-Δ51 (Sequence ID No. 5I) is identical to pCMV-26-NotI-24, except that it lacks 15-base pairs (i.e., nucleotides 1960-1974 of Sequence ID No. 5) and 51-base pairs (i.e., nucleotides 2351-2401 of Sequence ID No. 5).

Additional full-length NMDAR2C constructs can readily be prepared as described herein. For example, 5' untranslated sequence obtained from NMDA27 (instead of NMDA26) can be employed, and the 3' ends of the constructs can be contributed by various combinations of clones NMDA21, NMDA22, and NMDA24.

Several methods (e.g., nucleic acid amplification, RNase protection assays, etc.), as described in Example 2, can be employed to determine which NMDAR2C subunit variants are actually expressed in various human tissues.

Human NMDAR2C has 83.5% GC nucleotide content between nucleotides 2957 and 3166. To potentially enhance NMDAR2D subunit expression, the GC content in this region can be reduced while maintaining the native amino acid sequence. Synthetic DNAs can be made by oligonucleotide primer extension across this region. Four oligonucleotides, SE343 (Sequence ID No. 17), SE344 (Sequence ID No. 18), SE345 (Sequence ID No. 19), and SE346 (Sequence ID No. 20) were synthesized. These primers maintain the amino acid sequence of the human NMDAR2D receptor and some restriction sites, but lower the overall GC content of this region to 53.4%. The criteria for the modification of bases were: 1) to not have more than 4 guanine nucleotides in a row if at all possible, 2) to maintain the restriction cutting sites for *Not*I (nucleotides 2962 - 2969 of Sequence ID No. 5), *Ava*II (nucleotides 3069 - 3073 Sequence ID No.5), and *Aat*II (nucleotides 3156 - 3161 of Sequence ID No. 5), 3) to

reduce the secondary structure of the oligonucleotides as much as possible, 4) to not introduce any additional *Not*I, *Ava*II or *Aat*II restriction sites into the sequence and 5) to have the basepair overlap between oligonucleotide pairs, {SE343 and SE344} or {SE345 and SE346} have a proposed melting temperature between 62-66°C. The oligonucleotide pair SE343 and SE344 have complementary sequence from nucleotides 51 - 71 of Sequence ID Nos. 17 and 18. The oligonucleotide pair SE345 and SE346 have complementary sequence from nucleotides 42 - 61 of Sequence ID No. 19 and nucleotides 43 - 62 of Sequence ID No. 20, resepectively.

The primer pairs, {SE343 and SE344} and {SE345 and SE346}, are combined in a standard PCR reaction mixture, which contains 50 pmoles of each oligonucleotide, and are amplified according to the following PCR protocol:

> Annealing temperature of 55°C for 1 min, extension temperature of 72°C for 2 min and melting temperature, 96°C for 30 seconds for 30 cycles.

The resulting 121 bp PCR product from the primer pair SE343-SE344 is digested with *Not*I and *Ava*I, and the resulting 103 bp PCR product from the primer pair SE345-SE346 is digested with *Ava*I and *Aat*II. These fragments are ligated into pCMV-NMDAR2C-26-NotI-24, which has been partially digested with both *Not*I and *Aat*II due to the presence of additional *Not*I and/or *AatII* restriction sites in the vector sequence, to form pCMV-26-NotI-24-GCMOD. This construct, pCMV-26-NotI-24-GCMOD, contains nucleotides 140-2965 of Sequence ID No. 5, followed by the 195 nucleotides set forth in Sequence ID No. 21, and then nucleotides 3161 to 4340 of Sequence ID. No. 5.

Example 5

Isolation of DNA Encoding Human NMDA Receptor NMDAR2A Subunits

Two human cDNA libraries were prepared using different oligonucleotides (random and specific primers) to prime cDNA synthesis from RNA isolated from cerebellum tissue. The specific primer used for first-strand synthesis was SE162, nucleotides 904 to 929 of Sequence ID No. 10. cDNAs synthesized by random priming that ranged in size from 1.0-2.8 kb, and cDNAs synthesized by specific priming that ranged in size from 0.6-1.1 kb, were isolated and inserted into the λgt10 phage vector to generate the two libraries.

The random-primed library (3×10^6 recombinants) was screened for hybridization to the 795-base pair insert from pcrNMDAR2A (see Example 3) in 5X SSPE, 5X Denhart's solution, 50% deionized formamide, 0.2% SDS, 200 μg/ml sonicated, denatured herring sperm DNA at 42°C. Washes were performed in 1X SSPE, 0.2% SDS at 55°C. The probe hybridized to 11 plaques.

The specifically-primed library (6×10^5 recombinants) was screened for hybridization to oligonucleotide SE177 (nucleotides 859 to 884 of Sequence ID No. 10) in 6X SSPE, 5X Denhart's solution, 10% deionized formamide, 0.2% SDS, 200 μg/ml sonicated, denatured herring sperm DNA at 42°C. Washes were performed in 1X SSPE, 0.2% SDS at 50°C. The probe hybridized to 2 plaques.

Nine of the hybridizing plaques were purified and the inserts were characterized by restriction enzyme mapping and DNA sequence analysis. All clones contained partial cDNAs. Two of the clones, NMDA53 and NMDA54, contain the translation initiation codon and 320 base pairs and 88 base pairs, respectively, of 5' untranslated

sequence. The sequences of four other clones, NMDA47, NMDA49, NMDAR50 and NMDA51, along with those of NMDA53 and NMDA54, overlap to comprise ~70% of the human NMDAR2A subunit coding sequence (see nucleotides 1 - 3084 of Sequence ID No. 10).

To obtain clones containing the remaining ~1300 base pairs of 3' sequence needed to complete the NMDAR2A coding sequence, 6.6×10^6 recombinants of an additional human cDNA library (an amplified randomly primed cerebellum cDNA library with inserts ranging from 1.0 - 2.8 kb in length) were screened for hybridization to an oligonucleotide corresponding to the 3' end of clone NMDA51 (oligo SE171; nucleotide 3454 to 3479 of Sequence ID No. 10) using the same conditions as used for screening the specifically primed cerebellum cDNA library as described above. Four hybridizing plaques were purified and the inserts were characterized by DNA sequence analysis to determine if they contain the 3' end of the coding sequence and a translation termination codon. Two of the clones (NMDA57 and NMDA58, which were determined to be identical), contain a translation termination codon, as determined by DNA sequence analysis. Phage lysate containing clone NMDA57 were deposited under the provisions of the Budapest Treaty with the American Type Culture Collection (ATCC) on April 13, 1993, and assigned Accession No. 75442.

Example 6

Preparation of Full-length NMDAR2A Subunit cDNA Constructs

Two separate constructs encoding a full-length NMDAR2A subunit (pCMV-hNMDAR2A-1(53) and pCMV-hNMDAR2A-2(54) were prepared by ligating portions of the following partial NMDAR2A clones: NMDAR47, NMDAR50, NMDAR58 and either NMDAR53 or NMDAR54 (NMDAR53 and NMDAR54 differ only in the amount of 5' untranslated sequence contained in the clones. The inserts of clones NMDA47,

NMDA50 and NMDA58 were isolated as *Eco*RI fragments and ligated with *Eco*RI-digested pCMV-T7-2 to create pNMDA47, pNMDA50 and pNMDA58, respectively. The inserts of clones NMDA53 and NMDA54 were isolated as *Xho*I fragments and ligated with *Sal*I-digested pCMV-T7-2 to create pNMDA53 and pNMDA54, respectively.

pNMDA47 was digested with *Sca*I and *Nsi*I to liberate an ~3,350-bp fragment containing a 3' portion of the β-lactamase gene, which encodes a protein which imparts ampicillin-resistance, and nucleotides 824-2415 of Sequence ID No. 10. This fragment was ligated with a ~2890-bp *Nsi*I/*Sca*I fragment of pNMDA50 (containing a 5' portion of the β-lactamase gene and nucleotides 2416-3346 of Sequence ID No. 10) to generate pNMDA47+50.

The portion of pNMDA58 that encodes the 3' end of NMDAR2A contains two *Msc*I sites. Because the 3' *Msc*I site is cleaved in preference to the 5' *Msc*I site, partial digestion of pNMDA58 was not an option. Thus, pNMDA58 was digested with *Sca*I/*Msc*I, and the ~2020-bp fragment containing a 5' portion of the β-lactamase gene and a 3' portion of the insert (nucleotides 4751-4808 of Sequence ID No. 10) was isolated. This fragment was ligated to a ~4150-bp *Sca*I/*Msc*I fragment of pNMDA47+50 (containing a 3' portion of the β-lactamase gene and nucleotides 824-3212 of Sequence ID No. 10) to generate pNMDA47+50+3'END58. This plasmid contained a complete β-lactamase gene and nucleotides 824-3214 and 4751-4808 of Sequence ID No. 10. To add nucleotides 343-4750 of Sequence ID No. 10 to pNMDA47+50+3'END58, pNMDA58 was digested with *Msc*I, and the isolated 1537-bp fragment consisting of nucleotides 3213-4750 of Sequence ID No. 10 was ligated to *Msc*I-digested pNMDA47+50+3'END58. The resulting plasmid, pNMDA47+50+58, contained nucleotides 824-4808 of Sequence ID No. 10.

To generate two constructs containing identical NMDAR2A coding sequences but differing amounts of 5' untranslated sequence, pNMDA53 and pNMDA54 were digested with *Sca*I/*Eco*RI to liberate fragments containing a 3' portion of the β-lactamase gene and nucleotides 1-854 and 225-854 of Sequence ID No. 10, respectively. pNMDA47+50+58 was digested with *Sca*I/*Eco*RI (partial) and the 3954-bp fragment containing a 5' portion of the β-lactamase gene and nucleotides 855-4808 of Sequence ID No. 10 was separately ligated with the *Sca*I/*Eco*RI fragments of pNMDA53 and pNMDA54 to generate pCMV-hNMDAR2A-1(53) and pCMV-hNMDAR2A-2(54), respectively. These two constructs are identical except for the amount of 5' untranslated sequence contained in each. Both contain a full-length NMDAR2A-encoding sequence (nucleotides 311-4705 of Sequence ID No. 10) and 103 nucleotides of 3' untranslated sequence (nucleotides 4706-4808 of Sequence ID No. 10). pCMV-hNMDAR2A-1(53) contains 310 nucleotides of 5' untranslated sequence (nucleotides 1-310 of Sequence ID No. 10), whereas pCMV-hNMDAR2A-2(54) contains 87 nt of 5' untranslated sequence (nucleotides 224-310 of Sequence ID No. 10). The NMDAR2A cDNA is operatively linked to the regulator elements of pCMV-T7-2 for expression in mammalian host cells.

There is no unique restriction site 3' of the NMDAR2A-specific DNA in pCMV-hNMDAR2A-1(53) that can be used to linearize the plasmid in order to prepare *in vitro* transcripts for injection into *Xenopus* oocytes. To make a construct that has a unique 3' restriction site (pCMV-hNMDAR2A-3(53)), essentially the entire NMDAR2A-specific DNA of pCMV-hNMDAR2A-1(53) was transferred into vector pCMV-T7-3 as follows. pCMV-NMDAR2A-1(53) was digested with *Not*I and the ~4.4-kb fragment was isolated and ligated with *Not*I-digested pCMV-T7-3 to generate pCMV-hNMDAR2A-3(53).

Example 7

Isolation of DNA Encoding Human NMDA Receptor NMDAR2B Subunits

A human fetal brain λZAP cDNA library (1×10^6 recombinants; Stratagene, La Jolla, CA) was screened for hybridization to a DNA fragment containing the entire rat NMDAR2B subunit coding sequence (see Monyer et al. (1992) Science 256:1217-1221). Hybridization was conducted in 50% deionized formamide, 5X Denhart's solution, 5X SSPE, 200 μg/ml sonicated, denatured herring sperm DNA and 0.2% SDS at 42°C. Washes were performed in 0.5X SSPE, 0.2% SDS at 65°C. One of the hybridizing clones excised from the human fetal brain library, NMDA81, containing a 5,435 bp insert and translation initiation and termination codons, encodes a full-length NMDAR2B subunit. This excised plasmid, which is in the pBluescript vector, was called pBS-hNMDAR2B.

NMDA81 was digested with *Eco*RI/*Eco*RV and the ~5.5-kbp fragment was isolated and ligated to *Eco*RI/*Eco*RV-digested pCMV-T7-3. The resulting construct, pCMVPL3-hNMDAR2B, contains the NMDAR2B coding sequence (nucleotides 210-4664 of Sequence ID No. 13), as well as 209 nucleotides of 5' untranslated sequence (nucleotides 1-209 of Sequence ID No. 13) and 339 nucleotides of 3' untranslated sequence (nucleotides 4665-5003 of Sequence ID No. 13). The NMDAR2B-encoding DNA in this construct is operatively linked to regulatory elements in pCMV-T7-3 for expression in mammalian host cells.

Example 8

Isolation of DNA Encoding Human NMDA Receptor NMDAR2D subunits

A human fetal brain cDNA library (1×10^6 recombinants; Stratagene, La Jolla, CA) was screened by subtraction screening methods for DNA encoding a human

NMDAR2D receptor subunit. In this method, plaques were selected on the basis of weak or no hybridization to DNAs encoding human NMDAR2A, NMDAR2B and NMDAR2C subunits.

Initially, the library was screened for hybridization to pcrNMDAR2A (see Example 3) under low-stringency conditions (30% deionized formamide, 5X Denhart's solution, 5X SSPE, 200 ng/ml sonicated herring sperm DNA, 0.2% SDS at 42°C). Washes were also performed using low-stringency conditions (2X SSPE, 0.2% SDS, 50°C). The filters were stripped, then screened for hybridization to the pcrNMDAR2A fragment and to an ~1200 bp PstI fragment of DNA encoding a human NMDAR2B subunit (see Example 7) and an ~950 bp AccI fragment of DNA encoding a human NMDAR2C subunit (see Example 3). These fragments contain DNA encoding all of the putative transmembrane domains of the subunits. Hybridization was performed under high-stringency conditions (50% deionized formamide, 5X Denhart's solution, 5X SSPE, 200 ng/ml sonicated herring sperm DNA, 0.2% SDS at 42°C) as were washes (0.1X SSPE, 0.1% SDS, 65°C).

Eighteen of the plaques that hybridized weakly to pcrNMDAR2A in the initial low stringency screening of the library hybridized only weakly or not at all to portions of DNA encoding human NMDAR2A, NMDAR2B and NMDAR2C subunits in the high stringency screening. The plaques were purified, and the insert fragments were characterized by DNA sequence analysis. One of the inserts, NMDA96, corresponds to the 3' half of the human NMDAR2D subunit gene coding sequence. The sequence of this clone is provided in Sequence ID No. 15.

To obtain clones containing the remaining ~2000 bp of 5' sequence needed to complete the NMDAR2D subunit coding sequence, the human fetal brain cDNA library was screened for hybridization to an ~831 bp *Sma*I fragment of

the clone containing the 3' half of the NMDAR2D coding sequence under high stringency hybridization and washing with 0.5X SSPE, 0.2% SDS at 65°C. Nine hybridizing plaques were purified and analyzed by DNA sequencing, which revealed that none of the plaques contain DNA encoding a translation initiation codon and extending 3' to at least the 5' end of the clone containing the 3' half of the NMDAR2D coding sequence.

A human cDNA library was prepared using a specific oligonucleotide, SE296, to prime cDNA synthesis from RNA isolated from human fetal brain. The specific primer used for first-strand synthesis was SE296 (nucleotides 2920-2949 of Sequence ID No. 15). cDNAs synthesized by specific priming that were greater than 2.2 kb in size were isolated and inserted into the λZAPII phage vector to generate the library.

The specifically primed library (1×10^6 recombinants) was screened for hybridization to the 831 bp *Sma*I fragment from NMDAR2D (nucleotides 2435-3265 of Sequence ID No. 15) in 5X SSPE, 5X Denhart's solution, 50% deionized formamide, 0.2% SDS, 200 μg/ml sonicated, denatured herring sperm DNA at 42°C. Washes were performed in 0.1X SSPE, 0.2% SDS at 65°C. One probe hybridized to 11 plaques.

Eleven of the hybridizing plaques were purified, and the inserts characterized by restriction enzyme mapping and DNA sequence analysis. Six of the clones (NMDA111, NMDA112, NMDA115, NMDA116, NMDA119 and NMDA121) contain the translation initiation codon and varying amounts of 5' untranslated sequence.

The sequences of these clones overlap with NMDA96 to constitute 100% of the human NMDAR2D subunit coding sequence (see nucleotides 485-4495 of Sequence ID No. 15).

The full-length hNMDAR2D construct was prepared using NMDA115 and NMDA96 cDNAs. NMDA115 and NMDA96 cDNAs are already in the pBlueScript vector, however the NMDA115 cDNA is in the sense orientation from the T7 promoter, while the NMDA96 cDNA is in the antisense orientation. For ease of subcloning the full-length construct, the NMDA96 cDNA was cloned into the sense orientation by digesting NMDA96 with *Eco*RI and screening the resulting clones for orientation (NMDAR96-T7). Within the complete human NMDAR2D sequence, there is a unique *Hin*dIII at nucleotides 2804 that was used to clone NMDA115 together with NMDA96. However, there is an additional *Hin*dIII site in the pBS polylinker at the 5' end of the NMDA115 cDNA. Therefore NMDA115 was fully digested with *Spe*I, a 3' polylinker site, and partially digested with *Hin*dIII. The resulting ~5.6 kb *Spe*I-*Hin*dIII fragment from pNMDA115 (pBS vector plus nucleotides 397-2804 of Sequence ID No. 15)) was ligated with the 1.7 kb *Hin*dIII-*Spe*I fragment (nucleotides 2805-4651 of Sequence ID No. 15) from NMDA96-T7 to form pBS-hNMDAR2D. *In vitro* transcripts were prepared for co-injection into *Xenopus* oocytes to test for alteration of NMDAR1A currents.

The complete NMDAR2D insert is then transfered into the pMMTV-T7+ mammalian expression vector as a ~4.7 kb *Eco*RV/*Spe*I fragment. The *Eco*RV and *Spe*I restriction sites are in the multiple cloning region of the pBluscript vector.

In summary, construct NMDAR2D contains 88 base pairs of 5' untranslated sequence (nucleotides 397-484 in Sequence ID No. 15), the complete coding sequence for the NMDAR2D subunit (nucleotides 484-4495 of Sequence ID No. 15) as well as 200 base pairs of 3' untranslated sequence (nucleotides 4496-4695 of Sequence ID No. 15). The NMDAR2D subunit encoding sequence is operatively linked to the

regulatory elements in pMMTV-T7 for expression in mammalian cells.

Example 9
Expression of Recombinant Human NMDA Receptor Subunits on Oocytes

Xenopus oocytes were injected with *in vitro* transcripts prepared from constructs containing DNA encoding human NMDA receptor NMDAR1 and NMDAR2 subunits. Electrophysiological measurements of the oocyte transmembrane currents were made using the two-electrode voltage clamp technique (see e.g., Stuhmer (1992) *Meth. Enzymol. 207*:319-339).

A. Preparation of *In Vitro* Transcripts

Recombinant capped transcripts of NMDA receptor subunit cDNAs contained in constructs NMDAR1A, NMDAR1-I63, NMDAR1-I63-Δ204, NMDAR1-Δ1087, NMDAR1-Δ363, and pCMV-26-NotI-24 were synthesized from linearized plasmids using the mCAP RNA Capping Kit (Cat. #200350, Stratagene, Inc., La Jolla, CA). For experiments in which NMDAR2A or NMDAR2B and NMDAR1 or NMDAR1-I63 transcripts were co-injected into *Xenopus* oocytes, the transcripts were synthesized from linearized constructs NMDAR1A, NMDAR1-I63, pCMV-hNMDAR2A-3(53), pCMV-26-*Not*I-24 and pBS-hNMDAR2B using mMessage mMachine (Ambion, catalog #1344, Austin, TX). The mass of each synthesized transcript was determined by UV absorbance and the integrity of each transcript was determined by electrophoresis through an agarose gel.

B. Electrophysiology

Xenopus oocytes were injected with 12.5-50 ng of one or more NMDA receptor subunit transcripts per oocyte. The preparation and injection of oocytes were carried out

as described by Dascal [(1987) *Crit. Rev. Biochem. 22*:317-387]. Two-to-six days following mRNA injection, the oocytes were examined using the two-electrode voltage clamp technique. The cells were bathed in Ringer's solution (115 mM NaCl, 2.5 mM KCl, 1.8 mM $CaCl_2$, 10 mM HEPES, pH 7.3), and the membrane potential was clamped at -80 to -100 mV. Drugs were applied by pipetting 6.0 μl aliquots of drug-containing solution directly into the bath, or by using gravity-feed into a Warner Instruments chamber (volume = 110 μl) at a flow rate of 8 ml/min. The data were sampled at 2-5 Hz with a Labmaster data acquisition board in a PC-386 using AXOTAPE version 1.2 (Axon Instruments, Foster City, CA) software. The data were exported to a laser printer or plotted using Sigmaplot version 5.0.

NMDA agonists, i.e., 10-30 μM glycine (gly) and 10-100 μM glutamate (glu) or 100-1000 μM NMDA, were applied to the bath. If a current response was observed, the agonists were washed from the bath and 0.1-1.0 mM $MgCl_2$ or 1 μM MK801 (Research Biochemicals, Inc., Natick, MA) (NMDA receptor antagonists) were applied before a second agonist application in order to determine whether the current was blocked by antagonists. Alternatively, $MgCl_2$ or MK-801 were applied during agonist-induced current flow. The results of multiple recordings are summarized in Table 1.

Table 1

Electrophysiological Analysis of Oocytes Injected with NMDA Receptor Subunit Transcripts

Transcript (ng injected)	No. Oocytes Responding	Agonists	Peak Current Amplitude
NMDAR1A (12.5)	6 of 8[a]	10 μM gly + 10 μM glu	3-40 nA*
NMDAR1A (12.5)	2 of 2[a]	10 μM gly + 100 μM NMDA	3-8 nA
NMDAR1A (12.5)	0 of 9[a]	10 μM gly + 10 μM glu	
NMDAR1A (50)	0 of 1[a]	20 μM gly + 20 μM glu	
NMDAR1A (40)	4 of 10	10 μM gly + 10 μM glu	21.3 ± 20.9 nA*
NMDAR1A (40)	1 of 5	10 μM gly + 100 μM NMDA	24 nA*
NMDAR1A (40)	1 of 1	10 μM gly + 100 μM NMDA	15.4 nA
NMDAR1A (30)	4 of 9	10 μM gly + 50 μM glu	10.6 ± 11.7 nA*
NMDAR1A (30)	0 of 8	10-20 μM gly + 10-100 μM glu	
NMDAR1A (30)	1 of 4	20 μM gly + 100 μM NMDA	10.5 nA
NMDAR1A (25-50)	3 of 3	30 μM gly + 100 μM glu	3-10 nA
NMDAR1-I63 (12.5)	1 of 5[a]	10 μM gly + 10 μM glu	~30 nA*
NMDAR1-I63 (50)	0 of 4[a]	10 μM gly + 10 μM glu	
NMDAR1-I63 (40)	4 of 5	10 μM gly + 10 μM glu	13.4 ± 7.1 nA+
NMDAR1-I63 (40)	3 of 3	10 μM gly + 20 μM glu	17.4 ± 3.7 nA*
NMDAR1-I63 (40)	1 of 1	10 μM gly + 100 μM glu	28 nA
NMDAR1-I63 (40)	1 of 1	10 μM gly + 10 μM NMDA	1.4 nA+

Transcript (ng injected)	No. Oocytes Responding	Agonists	Peak Current Amplitude
NMDAR1-I63 (25-50)	3 of 3	10 μM gly + 100 μM glu	3-5 nA
NMDAR1-I63 (40)	7 of 10	10 μM gly + 100 μM NMDA	8.1 ± 3.0 nA[+]
NMDAR1-I63 (40)	1 of 2	10 μM gly + 1000 μM NMDA	16.4 nA[+]
NMDAR1-I63-Δ204 (12.5)	0 of 8[a]	10 μM gly + 10 μM glu	
NMDAR1-I63-Δ204 (50)	1 of 5[a]	20 μM gly + 20 μM glu	~50 nA
NMDAR1-Δ1087 (50)	3 of 13	10 μM gly + 10 μM glu	4-11 nA*
NMDAR1A (39) + pCMV-26-NotI-24 (39)	1 of 5	10 μM gly + 50 μM glu	10 nA
NMDAR1A (30) + pCMV-26-NotI-24 (30)	0 of 7	10 μM gly + 20 μM glu	
NMDAR1A (32) + pcDNA1-26-NotI-24-5'UT (50)	4 of 5	10 μM gly + 10 μM glu	15.8 ± 2.6 nA
NMDAR1A (25-50) + pCMV-hNMDAR2A-3(53) (25-50)	16 of 29	30 μM gly + 100 μM glu	40 nA - 3.4 μA
NMDAR1-I63 (25-50) + pCMV-hNMDAR2A-3(53) (25-50)	6 of 11	10 μM gly + 100 μM glu	10 - 100 nA
NMDAR1A (25) + pBS-hNMDAR2B (25)	4 of 5	30 μM gly + 30 μM glu	>100 nA
NMDAR1A (50) + pCMV-hNMDAR2A-3 (50) + pCMV-26-NotI-24 (50)	15 of 22	100 μM NMDA + 30 μM gly -or- 100 μM NMDA + 100 μM gly	137.7 nA 1340.1 nA

a Oocytes were unhealthy (i.e., the holding current was large)

* The agonist-induced currents in at least 1 cell were blocked by 100 μM $MgCl_2$.

+ The agonist-induced currents in at least 1 cell were blocked by 1.0 μM MK801.

Analysis of the results shown in Table 1 indicates that, in general, the NMDA agonist-induced currents were blocked by either $MgCl_2$ or MK801.

Oocytes injected with transcripts (12.5 to 65 ng) of the NMDAR-1 subunit-encoding inserts of constructs NMDAR1A, NMDAR1-I63 or NMDAR1-Δ363 were further analyzed to evaluate human NMDA receptor sensitivity to glutamate and NMDA. The two-electrode voltage clamp methods described above were used to measure current in the cells.

To determine glutamate and NMDA sensitivity of the recombinant human NMDA receptors, various concentrations of glutamate (0.1 - 100 μM) or NMDA (3-1000 μM) were applied to the bath (in the presence of 10-30 μM glycine) and the current response was recorded. The bath was flushed between agonist applications. Intermediate test applications of 10 μM glycine plus 10 μM glutamate were included in the experiments to monitor the receptors for run-down (i.e., inactivation of receptors that have been repeatedly activated during prolonged electrophysiological recording). The data were used to generate dose-response curves from which EC_{50} values for the two agonists were calculated. Glycine sensitivity was determined in the same manner except that various concentrations (0.1-100 μM) of glycine were co-applied with 100 μM NMDA.

The EC_{50} values determined for glutamate stimulation of NMDA receptors expressed in oocytes injected with NMDAR1A, NMDAR1-I63 or NMDAR1-Δ363 transcripts were 0.4, 0.6 and 0.5 μM, respectively. The EC_{50} values determined for NMDA stimulation of NMDA receptors expressed in oocytes injected with NMDAR1A, NMDAR1-I63 or NMDAR1-Δ363 transcripts were 6.3, 10.9 and 11.9 μM, respectively.

There was a marked potentiation of the current magnitude in response to glutamate and glycine in oocytes co-injected with *in vitro* transcripts of pCMV-hNMDAR2A-3(53) and NMDAR1A or NMDAR1-I63 compared to the currents recorded in oocytes injected with transcripts of either NMDAR1A or NMDAR1-I63 alone. Similarly, there was a marked potentiation of the current magnitude in response to glutamate and glycine in oocytes co-injected with *in vitro* transcripts of NMDAR1A and pBS-hNMDAR2B compared to the currents recorded in oocytes injected with only the NMDAR1A transcript.

To investigate the pharmacological properties of human NMDA receptors generated by coexpression of the human NMDAR1A, NMDAR2A and NMDAR2C subunits, oocytes were co-injected with 50 ng each of <u>in vitro</u> transcripts prepared from the NMDAR1A, pCMV-hNMDAR2A-3, and pCMV-26-NotI-24 (NMDAR2C) constructs. The sensitivity of the recombinant heteromeric receptors to glycine and NMDA was determined as described above. The EC_{50} for glycine activation of inward currents in these recombinant oocytes was calculated from the dose-response curve to be 0.87 ± 0.24 μM (mean ± S.D. of 4 oocytes), which was significantly different than the EC_{50} calculated for glycine sensitivity of oocytes injected with 50 ng each of <u>in vitro</u> transcripts of NMDAR1A and pCMV-hNMDAR2A-3 alone (1.9 ± 0.26 μM, ; $p = 0.0002$, one-tailed t-test). The sensitivity to NMDA also increased when human NMDAR2C was co-expressed with human NMDAR1A and NMDAR2A subunits. The EC_{50} for NMDA was shifted from 30.2 ± 9.4 μM for oocytes co-injected with 50 ng each of in vitro transcripts of NMDAR1A and pCMV-hNMDAR2A-3 to 11.9 ± 5.2 μM for oocytes co-injected with 50 ng each of <u>in vitro</u> transcripts of NMDAR1A, pCMV-hNMDAR2A-3 and pCMV-26-NotI-24 (mean ± S.D. of 4 oocytes).

Example 10

Recombinant Expression of Human NMDA Receptor Subunits in Mammalian Cells

Mammalian cells, such as human embryonic kidney (HEK293) cells can be transiently and/or stably transfected with DNA encoding human NMDA receptor subunits (e.g., DNA encoding an NMDAR1 subunit or DNA encoding an NMDAR1 subunit and DNA encoding an NMDAR2 subunit such as pCMV-26-NotI-24, pCMV-hNMDAR2A-3(53) or pCMVPL3-hNMDAR2B). Transfectants are analyzed for expression of NMDA receptors using various assays, e.g., northern blot hybridization, electrophysiological recording of cell currents, Ca^{2+}-sensitive fluorescent indicator-based assays and [^{3}H]-MK801 binding assays.

A. Transient Transfection of HEK Cells

Two transient transfections were performed. In one transfection, HEK 293 cells were transiently transfected with DNA encoding an NMDAR1 (construct NMDAR1A) subunit. In another transfection, HEK 293 cells were transiently co-transfected with DNA encoding NMDAR1 (construct NMDAR1A) and NMDAR2C (pCMV-26-NotI-24) subunits. In both transfections, ~2 x 10^6 HEK cells were transiently transfected with 19 μg of the indicated plasmid(s) according to standard $CaPO_4$ transfection procedures [Wigler *et al.* (1979) *Proc. Natl. Acad. Sci. USA* 76:1373-1376]. In addition, 1 μg of plasmid pCMVβgal (Clontech Laboratories, Palo Alto, CA), which contains the *Escherichia coli* β-galactosidase gene fused to the CMV promoter, were co-transfected as a reporter gene for monitoring the efficiency of transfection. The transfectants were analyzed for β-galactosidase expression by direct staining of the product of a reaction involving β-galactosidase and the X-gal substrate [Jones (1986) *EMBO* 5:3133-3142]. Transfectants can also be analyzed for β-galactosidase

expression by measurement of β-galactosidase activity [Miller (1972) in *Experiments in Molecular Genetics*, pp.352-355, Cold Spring Harbor Press].

The efficiency of these transfections of HEK cells was typical of standard efficiencies (i.e., ~50%).

B. Stable Transfection of Mammalian Cells

Mammalian cells, such as HEK 293 cells, can be stably transfected using the calcium phosphate transfection procedure [*Current Protocols in Molecular Biology, Vol. 1*, Wiley Inter-Science, Supplement 14, Unit 9.1.1-9.1.9 (1990)]. Ten-cm plates, each containing 1-2 x 10^6 cells, are transfected with 10 ml of DNA/calcium phosphate precipitate in media containing approximately 19 μg of NMDA receptor subunit-encoding DNA and 1 μg of DNA encoding a selectable marker, for example, neomycin-resistance gene (i.e., pSV2neo). After ~14 days of growth in media containing typically 1 μg/ml G418, colonies form and are individually isolated using cloning cylinders. The isolates are then subjected to limiting dilution and screened to identify those that express NMDA receptors using, for example, methods described below.

C. Analysis of Transfectants

1. Northern Blot Hybridization Analysis

Total RNA was isolated from ~1 x 10^7 HEK cells co-transfected with NMDAR1 and pCMV-26-NotI-24, and 5-10 μg of RNA was used for northern hybridization analysis. Fragments from human neuronal NMDAR subunit-encoding plasmids were randomly primed and labeled with ^{32}P-dCTP Klenow incorporation and used as probes. The northern blot hybridization and wash conditions were as follows:

> hybridization in 5x SSPE, 5X Denhart's solution, 50% formamide, at 42°C followed by washing in 0.2x SSPE, 0.1% SDS, at 65°C.

Results of these studies revealed the transfectants expressed detectable levels of NMDAR1 and NMDAR2C mRNA of the appropriate size (based on the size of the cDNAs).

2. Fluorescent indicator-based assays

Activation of ligand-gated NMDA receptors by agonists leads to an influx of cations (both monovalent and divalent), including Ca^{2+}, through the receptor channel. Calcium entry into the cell through the channel can in turn induce release of calcium contained in intracellular stores. Monovalent cation entry into the cell through the channel can also result in an increase in cytoplasmic calcium levels through depolarization of the membrane and subsequent activation of voltage-dependent calcium channels. Therefore, methods of detecting transient increases in intracellular calcium concentration can be applied to the analysis of functional NMDA receptor expression. One method for measuring intracellular calcium

levels relies on calcium-sensitive fluorescent indicators.

Calcium-sensitive indicators, such as fluo-3 (Catalog No. F-1241, Molecular Probes, Inc., Eugene, OR) are available as acetoxymethyl esters which are membrane permeable. When the acetoxymethyl ester form of the indicator enters a cell, the ester group is removed by cytosolic esterases, thereby trapping the free indicator in the cytosol. Interaction of the free indicator with calcium results in increased fluorescence of the indicator; therefore, an increase in the intracellular Ca^{2+} concentration of cells containing the indicator can be expressed directly as an increase in fluorescence. An automated fluorescence detection system for assaying NMDA receptors has been described in commonly assigned pending US Patent Application No. 07/812,254 and corresponding PCT Patent Application No. US92/11090, incorporated by reference herein in their entirety.

Mammalian cells that have been transfected with DNA encoding NMDAR1 or NMDAR1 and NMDAR2 subunits can be analyzed for expression of functional recombinant NMDA receptors using the automated fluorescent indicator-based assay. The assay procedure is as follows.

Untransfected mammalian host cells (or host cells transiently transfected with pCMV-T7-2) and mammalian cells that have been transfected with NMDAR1 ± NMDAR2 subunit DNA are plated in the wells of a 96-well microtiter dish (Nunc Catalog No. 1-6708, available through Alameda Industries, Escondido, CA) that has been precoated with poly-L-lysine at a density of 2.5×10^5 cells/well and loaded with fluo-3 by incubation for 2 hours at 20°C in a medium containing 20 μM fluo-3, 0.2% Pluronic F-127 in HBS (125 mM NaCl, 5 mM KCl, 1.8 mM $CaCl_2$, 0.62 mM $MgCl_2$, 20 mM glucose, 20 mM HEPES, pH 7.4). The cells are then washed with assay

buffer (i.e. HBS). The microtiter dish is then placed into a fluorescence plate reader (e.g., Fluoroskan II, Lab Products International, Ltd., Raleigh, NC) and the basal fluorescence of each well is measured and recorded before addition of 10 μM glycine and 10 μM glutamate to the wells. The fluorescence of the wells is monitored repeatedly (75 readings at 0.63-sec intervals) following addition of agonist.

The fluorescence of the untransfected host cells preferably will not change after addition of glycine and glutamate, i.e., the host cells should not express endogenous excitatory amino acid receptors. The fluorescence of mammalian cells transfected with NMDAR1 ± NMDAR2 subunit DNA will increase after addition of glycine and glutamate if a sufficient number of functional NMDA receptors are expressed at the cell surface, and fluorescence readings are taken rapidly.

The resting potential of the membrane of some mammalian host cells may be relatively positive (e.g., -35 mV). Because activation of some NMDA receptors may be significantly reduced at relatively positive potentials, it may be necessary to lower the resting potential of the membrane of cells transfected with human NMDA receptor subunit-encoding DNAs prior to assaying the cells for NMDA receptor activity using the fluorescent indicator-based assay. This may be accomplished by adding valinomycin (~10 μM) to the transfected cells prior to adding NMDA receptor agonists to initiate the assay.

3. NMDA Receptor Ligand Binding Assays

Mammalian cells transfected with NMDAR1 ± NMDAR2 subunit DNAs can be analyzed for [^{3}H]-MK801 binding. An additional ligand-binding assay for NMDA receptors using

^{3}H-CGP39653 is also described below. Rat brain membranes are included in the binding assays as a positive control.

a. Preparation of Membranes

i. Buffy coat Homogenate from Rat Cerebral Cortex

Buffy coat membranes are prepared from rat brain cortices as described by Jones *et al.* [(1989) *J. Pharmacol. Meth. 21*:161]. Briefly, cortices from ten freshly thawed frozen rat brains are dissected and weighed. The tissue is homogenized in 20 volumes of 0.32 M ice-cold sucrose in a glass homogenizing tube using a Teflon pestle. The suspension is centrifuged at 1,000 x g for 10 minutes at 4°C. The supernatant is decanted and centrifuged at 20,000 x g for 20 minutes at 4°C. The pellet is resuspended in 20 volumes of ice-cold distilled water with a Polytron for 30 sec at setting 6. The suspension is centrifuged at 8,000 x g for 20 minutes at 4°C. The buffy coat pellet is rinsed gently with supernatant and then recentrifuged at 48,000 x g for 20 minutes at 4°C. The pellet is resuspended in 20 volumes of ice-cold distilled water with a Polytron and centrifuged again at 48,000 x g for 20 minutes. The wash step is repeated once more. The final suspension is divided into aliquots, centrifuged. Each pellet can be stored frozen at -20°C for 12 hrs or more before use.

ii. Membranes from Transfected and Untransfected Mammalian Cells

In order to prepare membranes from transfected and untransfected mammalian cells, the cells are scraped from the tissue culture plates, and the plates are rinsed with 5 ml of PBS (phosphate-buffered saline: 137 mM NaCl, 2.7 mM KCl, 10 mM Na_2HPO_4, 1.7 mM KH_2PO_4). The cells are centrifuged at low speed in a table-top centrifuge, and the cell pellet is rinsed with PBS. The cell pellet is resuspended in 20 ml of 10 mM Hepes buffer, pH 7.4, using

a Polytron at setting 3-6 for 30 seconds. The cell suspension is centrifuged at 48,000 x g for 20 minutes at 4°C. The supernatant is discarded, and the pellet is kept frozen for 12 hrs or more at -20°C.

b. [^{3}H]-MK801 Binding to NMDA Receptors

The binding of [^{3}H]-MK801 to NMDA receptors is carried out as described by Wong *et al.* [(1986) *Proc. Natl. Acad. Sci. USA 83*:7104], with a few minor changes. Thus, on the day of the assay, the rat brain and mammalian cell (transfected and untransfected) membrane pellets are resuspended in 50 volumes of 10 mM Hepes buffer, pH 7.4, using a 10-ml syringe and a 21-gauge needle, and incubated for 20 minutes at 37°C. The supernatant is centrifuged at 48,000 x g for 20 minutes at 4°C. The pellet is resuspended in 2 ml of 10 mM Hepes, pH 7.4 and centrifuged as described above. The wash step is repeated once more, and the pellet is resuspended in 10 ml of 10 mM Hepes, pH 7.4. The protein concentration is determined using the Biorad Bradford reagent. The pellet is finally resuspended in the assay buffer (10 mM Hepes, pH 7.4) at 1 mg/ml.

For binding studies, the membrane suspension is incubated in duplicate with 2.5 nM [^{3}H]-MK801 (New England Nuclear, Boston, MA) in a total volume of 0.5 ml assay buffer (10 mM Hepes, pH 7.4) in the presence and absence of 10 μM glutamate and 10 μM glycine for 60 or 120 min at 23°C. Bound radioactivity is separated from free radioactivity by rapid filtration through Whatman GF/C filters which are presoaked for 2-3 hrs in 0.05% polyethylenimine. The filters are washed twice with 3 ml ice-cold assay buffer. The filters are dried and transferred to scintillation vials, each containing 10 ml of scintillation fluid. The vials are vortexed, and the radioactivity is measured in a Beckman scintillation counter. The nonspecific binding observed in the presence

of 10 μM MK801 is subtracted from the total binding in order to determine the specific binding.

Rat brain cortical buffy coat membranes displayed specific saturable binding of [^{3}H]-MK801. In the presence of glycine and glutamate, the ratio of total-to-nonspecific binding (S:N ratio) was 28:1, whereas in the absence of glutamate and glycine the S:N ratio was 5:1. Thus, the binding of MK801 to rat NMDA receptors is potentiated by glutamatergic agonists. Scatchard analysis of [^{3}H]-MK801 binding to rat brain membranes indicated that the sensitivity of the assay was 90 fmoles of receptor.

c. [^{3}H]-CGP39653 Binding to NMDA Receptors

The binding of [^{3}H]-CGP39653 to rat brain membranes is carried out as described by Sills *et al.* [(1991) *Eur. J. Pharmacol. 192*:19]. The buffy coat membrane pellet is resuspended in 50 volumes of 5 mM Tris-HCl containing 10 mM EDTA, pH 7.7, and incubated for 10 min. at 37°C. The supernatant is centrifuged at 48,000 x g for 10 min. at 4°C. The wash step is repeated once and the pellet is resuspended in 10 ml of 5 mM Tris-HCl containing 10 mM EDTA, pH 7.7. This rat brain membrane suspension is incubated in duplicate or triplicate with 2.0 nM [^{3}H]-CGP39653 (New England Nuclear) in a total volume of 0.5 ml assay buffer (5 mM Tris-HCl, pH 7.7) for 60 min at 0°C. Nonspecific binding is determined in the presence of 100 μM glutamate. Bound radioactivity is separated from the free by vacuum filtration through GF/C filters which are presoaked for 2-3 hrs in 0.05% polyethylenimine, using the filtration manifold. Unbound radioactivity is removed with two washes of 3 ml each of ice-cold buffer. The filters are dried and transferred to scintillation vials, each containing 10 ml of scintillation fluid. The vials are vortexed, and the radioactivity is measured in a Beckman scintillation counter. The nonspecific binding observed in

the presence of 100 μM glutamate is subtracted from the total binding to determine the specific binding.

[^{3}H]-CGP39653 binding was first measured as a function of membrane concentration. Specific binding increased linearly with increasing membrane concentration up to 200 μg of protein in the presence of 2 nM [^{3}H]-CGP39653.

Saturation analysis of [^{3}H]-CGP39653 binding was carried out by incubating 150 μg of rat buffy coat homogenate with increasing concentrations of [^{3}H]-CGP39653 for 60 min at 4°C. Scatchard analysis indicated a single class of binding sites with a B_{max} value of 0.69 ± 0.09 pmoles/mg and a K_d value of 12.3 ± 0.12 nM.

While the invention has been described in detail with reference to certain preferred embodiments thereof, it will be understood that modifications and variations are within the spirit and scope of that which is described and claimed.

Summary of Sequences

Sequence ID No. 1 is a nucleotide sequence encoding a human N-methyl-D-aspartate (NMDA) receptor subunit, NMDAR1A, and the deduced amino acid sequence thereof.

Sequence ID No. 1A is a 3083 nucleotide sequence encoded by clone NMDA10, comprising nucleotides 320 - 3402 of Sequence ID No. 1. Thus, Sequence ID No. 1A differs from Sequence ID No. 1 in that it does not contain the 319 5' nucleotides, nor the 896 3' nucleotides thereof.

Sequence ID No. 1B is a 3155 nucleotide sequence encoded by clone NMDA11, comprising nucleotides 1 - 2961, plus nucleotides 3325 - 3518 of Sequence ID No. 1. Thus, Sequence ID No. 1B differs from Sequence ID No. 1 by the deletion of 363 nucleotides from the 3' portion thereof (i.e., by the deletion of nucleotides 2962 - 3324 of Sequence ID No. 1), and further by the lack of the 781 terminal 3' nucleotides of Sequence ID No. 1.

Sequence ID No. 1C is a 2542 nucleotide sequence encoded by clone NMDA7, comprising nucleotides 556 - 831 of Sequence ID No. 1, plus an additional 63 nucleotides (set forth in Sequence ID No. 3) and nucleotides 832 - 984, 1189 - 2961 and 3325 - 3599 of Sequence ID No. 1. Thus, Sequence ID No. 1C differs from Sequence ID No. 1 in that it does not contain the 555 5'-most nucleotides thereof, it does not contain the 204 nucleotides set forth as nucleotides 985 - 1188 of Sequence ID No. 1, it does not contain the 363 3' nucleotides set forth as nucleotides 2962 - 3324 of Sequence ID No. 1, and it does not contain the 700 3'-most nucleotides of Sequence ID No. 1, while it does contain an additional 63 nucleotides (Sequence ID No. 3) inserted between nucleotides 831 and 832 of Sequence ID No. 1.

Sequence ID No. 1D is a 593 nucleotide sequence encoded by clone NMDA3, comprising nucleotides 2617 - 2961, plus nucleotides 4049 - 4298 of Sequence ID No. 1. Thus, Sequence ID No. 1D differs from Sequence ID No. 1 in that it does not contain the 2616 5' nucleotides thereof, and by the deletion of 1087 nucleotides from the 3' portion thereof (i.e., by the deletion of nucleotides 2962 - 4048 of Sequence ID No. 1).

Sequence ID No. 1E is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-Δ363, comprising nucleotides 1 - 2961, plus nucleotides 3325 - 4298 of Sequence ID No. 1. Thus, Sequence ID No. 1E differs from Sequence ID No. 1 in that it does not contain the 363 nucleotides set forth as nucleotides 2962 - 3324 of Sequence ID No. 1.

Sequence ID No. 1F is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-Δ1087, comprising nucleotides 1 - 2961, plus nucleotides 4049 - 4298 of Sequence ID No. 1. Thus, Sequence ID No. 1F differs from Sequence ID No. 1 in that it does not contain the 1087 nucleotides set forth as nucleotides 2962 - 4048 of Sequence ID No. 1.

Sequence ID No. 1G is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-I63. Sequence ID No. 1G is the same as Sequence ID No. 1, further comprising an additional 63 nucleotides (set forth in Sequence ID No. 3) inserted between nucleotides 831 and 832 of Sequence ID No. 1.

Sequence ID No. 1H is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-I63-Δ204. Sequence ID No. 1H is the same as Sequence ID No. 1G, except Sequence ID No. 1H does not contain the 204

nucleotides set forth as nucleotides 985 - 1188 of Sequence ID No. 1.

Sequence ID No. 1I is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-I63-Δ204-Δ363. Sequence ID No. 1I is the same as Sequence ID No. 1H, except Sequence ID No. 1I does not contain the 363 nucleotides set forth as nucleotides 2962 - 3324 of Sequence ID No. 1.

Sequence ID No. 1J is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-Δ204. Sequence ID No. 1J is the same as Sequence ID No. 1, except Sequence ID No. 1J does not contain the 204 nucleotides set forth as nucleotides 985 - 1188 of Sequence ID No. 1.

Sequence ID No. 1K is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-Δ204-Δ363. Sequence ID No. 1K differs from Sequence ID No. 1 in that Sequence ID No. 1K does not contain the 204 nucleotides set forth as nucleotides 985 - 1188 of Sequence ID No. 1, nor the 363 nucleotides set forth as nucleotides 2962 - 3324 of Sequence ID No. 1.

Sequence ID No. 1L is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-Δ204-Δ1087. Sequence ID No. 1L differs from Sequence ID No. 1 in that Sequence ID No. 1L does not contain the 204 nucleotides set forth as nucleotides 985 - 1188 of Sequence ID No. 1, nor the 1087 nucleotides set forth as nucleotides 2962 - 4048 of Sequence ID No. 1.

Sequence ID No. 1M is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-I63-Δ363. Sequence ID No. 1M is the same as Sequence ID No. 1G except Sequence ID No. 1M does not contain the 363 nucleotides set forth as nucleotides 2962 - 3324 of Sequence ID No. 1.

Sequence ID No. 1N is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-I63-Δ1087. Sequence No. 1N is the same as Sequence ID No. 1G except Sequence ID No. 1N does not contain the 1087 nucleotides set forth as nucleotides 2962 - 4048 of Sequence ID No. 1.

Sequence ID No. 1P is a nucleotide sequence encoding human NMDA receptor subunit NMDAR1-I63-Δ204-Δ1087. Sequence ID No. 1P is the same as Sequence ID No. 1H, except Sequence ID No. 1P does not contain the 1087 nucleotides set forth as nucleotides 2962 - 4048 of Sequence ID No. 1.

Sequence ID No. 2 is the amino acid sequence of the NMDA receptor subunit set forth in Sequence ID No. 1.

Sequence ID No. 2A is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 1A.

Sequence ID No. 2B is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1B.

Sequence ID No. 2C is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 1C.

Sequence ID No. 2D is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 1D.

Sequence ID No. 2E is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1E.

Sequence ID No. 2F is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1F.

Sequence ID No. 2G is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1G.

Sequence ID No. 2H is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1H.

Sequence ID No. 2I is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1I.

Sequence ID No. 2J is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1J.

Sequence ID No. 2K is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1K.

Sequence ID No. 2L is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1L.

Sequence ID No. 2M is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1M.

Sequence ID No. 2N is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1N.

Sequence ID No. 2P is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 1P.

Sequence ID No. 3 is a nucleotide sequence encoding the 63 nucleotide insert present in Sequence ID Nos. 1C, 1G, 1H, 1I, 1M, 1N and 1P.

Sequence ID No. 4 is the 21 amino acid sequence encoded by the insert set forth in Sequence ID No. 3.

Sequence ID No. 5 is a nucleotide sequence of a clone (pCMV-26-*Not*I-24) encoding a human N-methyl-D-aspartate (NMDA) receptor subunit, NMDAR2C, and the deduced amino acid sequence thereof.

Sequence ID No. 5A is a 2026 nucleotide sequence encoded by clone NMDA21, comprising nucleotides 931 - 2350, and 2402 - 3307 of Sequence ID No. 5. Thus, Sequence ID No. 5A differs from Sequence ID No. 5 in that it does not contain the 930 5' nucleotides thereof, nor the 51 nucleotides located at position 2351 - 2401 of Sequence ID No. 5, nor the 1061 3' nucleotides of Sequence ID No. 5.

Sequence ID No. 5B is a 3698 nucleotide sequence encoded by clone NMDA22, comprising nucleotides 367 - 1300 of Sequence ID No. 5, plus an additional 11 nucleotides (set forth as Sequence ID No. 9), and nucleotides 1301 - 1959 and 1975 - 4068 of Sequence ID No. 5. Thus, Sequence ID No. 5B differs from Sequence ID No. 5 by the lack of the 366 5'-most nucleotides, by the insertion of 11 nucleotides between nucleotides 1300 and 1301 of Sequence ID No. 5, and further by the lack of the 15 nucleotides of Sequence ID No. 5 from residue 1960 to residue 1974.

Sequence ID No. 5C is a 3243 nucleotide sequence encoded by clone NMDA24, comprising nucleotides 861 - 1300 of Sequence ID No. 5, plus an additional 11 nucleotides (Sequence ID No. 9), nucleotides 1301 - 2350 of Sequence ID No. 5, an additional 24 nucleotides (set forth as Sequence ID No. 7) and nucleotides 2351 - 4068 of Sequence ID No. 5. Thus, Sequence ID No. 5C differs from Sequence ID No. 5 in that it does not contain the 860 5'-most nucleotides thereof, while it does contain an additional 11 nucleotides (Sequence ID No. 9) inserted between nucleotides 1300 and 1301, plus an additional 24 nucleotides (Sequence ID No. 7) inserted between nucleotides 2350 and 2351 of Sequence ID No. 5.

Sequence ID No. 5D is a 3025 nucleotide sequence encoded by clone NMDA26, comprising nucleotides 1 - 3025 of Sequence ID No. 5. Thus, Sequence ID No. 5D differs from Sequence ID No. 5 in that it does not contain the 1043 3'-terminal nucleotides thereof.

Sequence ID No. 5E is a nucleotide sequence encoding human NMDA receptor subunit pCMV-26-*Sca*I-24, which differs from Sequence ID No. 5 only in the insertion of 24 nucleotides (Sequence ID No. 7) between nucleotides 2350 and 2351 of Sequence ID No. 5.

Sequence ID No. 5F is a nucleotide sequence encoding human NMDA receptor subunit pCMV-26-*Sca*I-22, which differs from Sequence ID No. 5 only in the deletion of nucleotides 1960 - 1974 of Sequence ID No. 5.

Sequence ID No. 5G is a nucleotide sequence encoding human NMDA receptor subunit pCMV-26-*Sca*I-21-*Not*I-24, which differs from Sequence ID No. 5 only in the deletion of nucleotides 2351 - 2401 of Sequence ID No. 5.

Sequence ID No. 5H is a nucleotide sequence encoding human NMDA receptor subunit NMDAR2C-Δ15-I24. Sequence ID No. 5H is the same as Sequence ID No. 5F, except Sequence ID No. 5H further contains the 24 nucleotide insert set forth in Sequence ID No. 7, positioned between nucleotides 2350 and 2351 of Sequence ID No. 5.

Sequence ID No. 5I is a nucleotide sequence encoding human NMDA receptor subunit NMDAR2C-Δ15-Δ51. Sequence ID No. 5I is the same as Sequence ID No. 5G, except Sequence ID No. 5I does not contain the 15 nucleotides set forth as nucleotides 1960 - 1974 of Sequence ID No. 5.

Sequence ID No. 6 is the amino acid sequence of the NMDA receptor subunit set forth in Sequence ID No. 5.

Sequence ID No. 6A is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 5A.

Sequence ID No. 6B is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 5B.

Sequence ID No. 6C is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 5C.

Sequence ID No. 6D is the amino acid sequence of a portion of an NMDA receptor subunit as encoded by the nucleotide sequence of Sequence ID No. 5D.

Sequence ID No. 6E is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 5E.

Sequence ID No. 6F is the amino acid sequence of an NMDA receptor subunit encoded by the nucleotide sequence of Sequence ID No. 5F.

Sequence ID No. 6G is the amino acid sequence of ceptor subunit encoded by the nucleotide sequence ice ID No. 5G.

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Sequence ID No. 6H is the amino acid sequence of receptor subunit encoded by the nucleotide sequence uence ID No. 5H.

ide sequence of f clone NMDA27, - 74) of said

Sequence ID No. 6I is the amino acid sequence of MDA receptor subunit encoded by the nucleotide sequence Sequence ID No. 5I.

quence of a) receptor

Sequence ID No. 7 is a nucleotide sequence ncoding the 24 nucleotide insert present in Sequence ID Nos. 5C, 5E and 5H.

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Sequence ID No. 8 is the 7 amino acid sequence encoded by nucleotides 2-22 of the insert set forth in Sequence ID No. 7. Because the insert is introduced within a codon, the insert itself only encodes 7 amino acids. The terminal residues of the nucleotide insert participate in forming codons with adjacent sequence at the site of insertion.

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Sequence ID No. 9 is a nucleotide sequence encoding the 11 nucleotide insert present in Sequence ID Nos. 5B and 5C.

Sequence ID No. 10 is a nucleotide sequence encoding a human N-methyl-D-aspartate (NMDA) receptor subunit, NMDAR2A.

Sequence ID No. 11 is the amino acid sequence of an NMDA receptor subunit as encoded by the nucleotide sequence set forth in Sequence ID No. 10.

Sequence ID No. 12 is the nucleotide sequence of 71 nucleotides of 5' untranslated sequence of clone NMDA27, plus the initiation codon (nucleotides 72 - 74) of said clone.

Sequence ID No. 13 is a nucleotide sequence of a clone encoding a human N-methyl-D-aspartate (NMDA) receptor subunit, NMDAR2B.

Sequence ID No. 14 is the amino acid sequence of the NMDA receptor subunit set forth in Sequence ID No. 13.

Sequence ID No. 15 is a nucleotide sequence of a clone encoding a human N-methyl-D-aspartate (NMDA) receptor subunit, NMDAR2D.

Sequence ID No. 16 is the amino acid sequence of the NMDA receptor subunit set forth in Sequence ID No. 15.

Sequence ID Nos. 17-20 are four synthetic oligonucleotides used in the preparation of an NMDAR2C clone (pCMV-26-NotI-24-GCMOD) having reduced GC nucleotide content between nucleotides 2957 and 3166.

Sequence ID No. 21 is the nucleotide sequence of the 195 basepair insert of NMDAR2C clone pCMV-26-NotI-24-GCMOD (replacing nucleotides 2966-3160 of Sequence ID No. 5).

SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: Daggett, Lorrie P.
Ellis, Steven B.
Liaw, Chen W.
Lu, Chin-Chun

(ii) TITLE OF INVENTION: HUMAN N-METHYL-D-ASPARTATE RECEPTOR SUBUNITS, DNA ENCODING SAME AND USES THEREFOR

(iii) NUMBER OF SEQUENCES: 21

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(v) COMPUTER READABLE FORM:
(A) MEDIUM TYPE: Floppy disk
(B) COMPUTER: IBM PC compatible
(C) OPERATING SYSTEM: PC-DOS/MS-DOS
(D) SOFTWARE: PatentIn Release #1.0, Version #1.25

(vi) CURRENT APPLICATION DATA:
(A) APPLICATION NUMBER:
(B) FILING DATE: 20-APR-1994
(C) CLASSIFICATION:

(vii) PRIOR APPLICATION DATA:
(A) APPLICATION NUMBER: US 08/052,449
(B) FILING DATE: 20-APR-1993

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(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 4298 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 262..3078

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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CAAGCCGGGC GTTCGGAGCT GTGCCCGGCC CCGCTTCAGC ACCGCGGACA GCGCCGGCCG      60

CGTGGGGCTG AGCGCCGAGC CCCCGCGCAC GCTTCAGCCC CCCTTCCCTC GGCCGACGTC     120

CCGGGACCGC CGCTCCGGGG GAGACGTGGC GTCCGCAGCC CGCGGGGCCG GGCGAGCGCA     180

GGACGGCCCG GAAGCCCCGC GGGGGATGCG CCGAGGGCCC CGCGTTCGCG CCGCGCAGAG     240

CCAGGCCCGC GGCCCGAGCC C ATG AGC ACC ATG CGC CTG CTG ACG CTC GCC        291
                        Met Ser Thr Met Arg Leu Leu Thr Leu Ala
                          1               5                  10

CTG CTG TTC TCC TGC TCC GTC GCC CGT GCC GCG TGC GAC CCC AAG ATC        339
Leu Leu Phe Ser Cys Ser Val Ala Arg Ala Ala Cys Asp Pro Lys Ile
                    15                  20                  25

GTC AAC ATT GGC GCG GTG CTG AGC ACG CGG AAG CAC GAG CAG ATG TTC        387
Val Asn Ile Gly Ala Val Leu Ser Thr Arg Lys His Glu Gln Met Phe
                30                  35                  40

CGC GAG GCC GTG AAC CAG GCC AAC AAG CGG CAC GGC TCC TGG AAG ATT        435
Arg Glu Ala Val Asn Gln Ala Asn Lys Arg His Gly Ser Trp Lys Ile
            45                  50                  55

CAG CTC AAT GCC ACC TCC GTC ACG CAC AAG CCC AAC GCC ATC CAG ATG        483
Gln Leu Asn Ala Thr Ser Val Thr His Lys Pro Asn Ala Ile Gln Met
        60                  65                  70

GCT CTG TCG GTG TGC GAG GAC CTC ATC TCC AGC CAG GTC TAC GCC ATC        531
Ala Leu Ser Val Cys Glu Asp Leu Ile Ser Ser Gln Val Tyr Ala Ile
 75                  80                  85                  90

CTA GTT AGC CAT CCA CCT ACC CCC AAC GAC CAC TTC ACT CCC ACC CCT        579
Leu Val Ser His Pro Pro Thr Pro Asn Asp His Phe Thr Pro Thr Pro
                95                  100                 105

GTC TCC TAC ACA GCC GGC TTC TAC CGC ATA CCC GTG CTG GGG CTG ACC        627
Val Ser Tyr Thr Ala Gly Phe Tyr Arg Ile Pro Val Leu Gly Leu Thr
            110                 115                 120

ACC CGC ATG TCC ATC TAC TCG GAC AAG AGC ATC CAC CTG AGC TTC CTG        675
Thr Arg Met Ser Ile Tyr Ser Asp Lys Ser Ile His Leu Ser Phe Leu
        125                 130                 135

CGC ACC GTG CCG CCC TAC TCC CAC CAG TCC AGC GTG TGG TTT GAG ATG        723
Arg Thr Val Pro Pro Tyr Ser His Gln Ser Ser Val Trp Phe Glu Met
    140                 145                 150

ATG CGT GTC TAC AGC TGG AAC CAC ATC ATC CTG CTG GTC AGC GAC GAC        771
Met Arg Val Tyr Ser Trp Asn His Ile Ile Leu Leu Val Ser Asp Asp
155                 160                 165                 170

CAC GAG GGC CGG GCG GCT CAG AAA CGC CTG GAG ACG CTG CTG GAG GAG        819
His Glu Gly Arg Ala Ala Gln Lys Arg Leu Glu Thr Leu Leu Glu Glu
                175                 180                 185

CGT GAG TCC AAG GCA GAG AAG GTG CTG CAG TTT GAC CCA GGG ACC AAG        867
Arg Glu Ser Lys Ala Glu Lys Val Leu Gln Phe Asp Pro Gly Thr Lys
            190                 195                 200

AAC GTG ACG GCC CTG CTG ATG GAG GCG AAA GAG CTG GAG GCC CGG GTC        915
Asn Val Thr Ala Leu Leu Met Glu Ala Lys Glu Leu Glu Ala Arg Val
        205                 210                 215
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ATC ATC CTT TCT GCC AGC GAG GAC GAT GCT GCC ACT GTA TAC CGC GCA        963
Ile Ile Leu Ser Ala Ser Glu Asp Asp Ala Ala Thr Val Tyr Arg Ala
    220                 225                 230

GCC GCG ATG CTG AAC ATG ACG GGC TCC GGG TAC GTG TGG CTG GTC GGC       1011
Ala Ala Met Leu Asn Met Thr Gly Ser Gly Tyr Val Trp Leu Val Gly
235                 240                 245                 250

GAG CGC GAG ATC TCG GGG AAC GCC CTG CGC TAC GCC CCA GAC GGC ATC       1059
Glu Arg Glu Ile Ser Gly Asn Ala Leu Arg Tyr Ala Pro Asp Gly Ile
                255                 260                 265

CTC GGG CTG CAG CTC ATC AAC GGC AAG AAC GAG TCG GCC CAC ATC AGC       1107
Leu Gly Leu Gln Leu Ile Asn Gly Lys Asn Glu Ser Ala His Ile Ser
            270                 275                 280

GAC GCC GTG GGC GTG GTG GCC CAG GCC GTG CAC GAG CTC CTC GAG AAG       1155
Asp Ala Val Gly Val Val Ala Gln Ala Val His Glu Leu Leu Glu Lys
        285                 290                 295

GAG AAC ATC ACC GAC CCG CCG CGG GGC TGC GTG GGC AAC ACC AAC ATC       1203
Glu Asn Ile Thr Asp Pro Pro Arg Gly Cys Val Gly Asn Thr Asn Ile
    300                 305                 310

TGG AAG ACC GGG CCG CTC TTC AAG AGA GTG CTG ATG TCT TCC AAG TAT       1251
Trp Lys Thr Gly Pro Leu Phe Lys Arg Val Leu Met Ser Ser Lys Tyr
315                 320                 325                 330

GCG GAT GGG GTG ACT GGT CGC GTG GAG TTC AAT GAG GAT GGG GAC CGG       1299
Ala Asp Gly Val Thr Gly Arg Val Glu Phe Asn Glu Asp Gly Asp Arg
                335                 340                 345

AAG TTC GCC AAC TAC AGC ATC ATG AAC CTG CAG AAC CGC AAG CTG GTG       1347
Lys Phe Ala Asn Tyr Ser Ile Met Asn Leu Gln Asn Arg Lys Leu Val
            350                 355                 360

CAA GTG GGC ATC TAC AAT GGC ACC CAC GTC ATC CCT AAT GAC AGG AAG       1395
Gln Val Gly Ile Tyr Asn Gly Thr His Val Ile Pro Asn Asp Arg Lys
        365                 370                 375

ATC ATC TGG CCA GGC GGA GAG ACA GAG AAG CCT CGA GGG TAC CAG ATG       1443
Ile Ile Trp Pro Gly Gly Glu Thr Glu Lys Pro Arg Gly Tyr Gln Met
    380                 385                 390

TCC ACC AGA CTG AAG ATT GTG ACG ATC CAC CAG GAG CCC TTC GTG TAC       1491
Ser Thr Arg Leu Lys Ile Val Thr Ile His Gln Glu Pro Phe Val Tyr
395                 400                 405                 410

GTC AAG CCC ACG CTG AGT GAT GGG ACA TGC AAG GAG GAG TTC ACA GTC       1539
Val Lys Pro Thr Leu Ser Asp Gly Thr Cys Lys Glu Glu Phe Thr Val
                415                 420                 425

AAC GGC GAC CCA GTC AAG AAG GTG ATC TGC ACC GGG CCC AAC GAC ACG       1587
Asn Gly Asp Pro Val Lys Lys Val Ile Cys Thr Gly Pro Asn Asp Thr
            430                 435                 440

TCG CCG GGC AGC CCC CGC CAC ACG GTG CCT CAG TGT TGC TAC GGC TTT       1635
Ser Pro Gly Ser Pro Arg His Thr Val Pro Gln Cys Cys Tyr Gly Phe
        445                 450                 455

TGC ATC GAC CTG CTC ATC AAG CTG GCA CGG ACC ATG AAC TTC ACC TAC       1683
Cys Ile Asp Leu Leu Ile Lys Leu Ala Arg Thr Met Asn Phe Thr Tyr
    460                 465                 470

GAG GTG CAC CTG GTG GCA GAT GGC AAG TTC GGC ACA CAG GAG CGG GTG       1731
Glu Val His Leu Val Ala Asp Gly Lys Phe Gly Thr Gln Glu Arg Val
475                 480                 485                 490
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AAC AAC AGC AAC AAG AAG GAG TGG AAT GGG ATG ATG GGC GAG CTG CTC          1779
Asn Asn Ser Asn Lys Lys Glu Trp Asn Gly Met Met Gly Glu Leu Leu
                495                 500                 505

AGC GGG CAG GCA GAC ATG ATC GTG GCG CCG CTA ACC ATA AAC AAC GAG          1827
Ser Gly Gln Ala Asp Met Ile Val Ala Pro Leu Thr Ile Asn Asn Glu
            510                 515                 520

CGC GCG CAG TAC ATC GAG TTT TCC AAG CCC TTC AAG TAC CAG GGC CTG          1875
Arg Ala Gln Tyr Ile Glu Phe Ser Lys Pro Phe Lys Tyr Gln Gly Leu
        525                 530                 535

ACT ATT CTG GTC AAG AAG GAG ATT CCC CGG AGC ACG CTG GAC TCG TTC          1923
Thr Ile Leu Val Lys Lys Glu Ile Pro Arg Ser Thr Leu Asp Ser Phe
    540                 545                 550

ATG CAG CCG TTC CAG AGC ACA CTG TGG CTG CTG GTG GGG CTG TCG GTG          1971
Met Gln Pro Phe Gln Ser Thr Leu Trp Leu Leu Val Gly Leu Ser Val
555                 560                 565                 570

CAC GTG GTG GCC GTG ATG CTG TAC CTG CTG GAC CGC TTC AGC CCC TTC          2019
His Val Val Ala Val Met Leu Tyr Leu Leu Asp Arg Phe Ser Pro Phe
                575                 580                 585

GGC CGG TTC AAG GTG AAC AGC GAG GAG GAG GAG GAG GAC GCA CTG ACC          2067
Gly Arg Phe Lys Val Asn Ser Glu Glu Glu Glu Glu Asp Ala Leu Thr
            590                 595                 600

CTG TCC TCG GCC ATG TGG TTC TCC TGG GGC GTC CTG CTC AAC TCC GGC          2115
Leu Ser Ser Ala Met Trp Phe Ser Trp Gly Val Leu Leu Asn Ser Gly
        605                 610                 615

ATC GGG GAA GGC GCC CCC AGA AGC TTC TCA GCG CGC ATC CTG GGC ATG          2163
Ile Gly Glu Gly Ala Pro Arg Ser Phe Ser Ala Arg Ile Leu Gly Met
    620                 625                 630

GTG TGG GCC GGC TTT GCC ATG ATC ATC GTG GCC TCC TAC ACC GCC AAC          2211
Val Trp Ala Gly Phe Ala Met Ile Ile Val Ala Ser Tyr Thr Ala Asn
635                 640                 645                 650

CTG GCG GCC TTC CTG GTG CTG GAC CGG CCG GAG GAG CGC ATC ACG GGC          2259
Leu Ala Ala Phe Leu Val Leu Asp Arg Pro Glu Glu Arg Ile Thr Gly
                655                 660                 665

ATC AAC GAC CCT CGG CTG AGG AAC CCC TCG GAC AAG TTT ATC TAC GCC          2307
Ile Asn Asp Pro Arg Leu Arg Asn Pro Ser Asp Lys Phe Ile Tyr Ala
            670                 675                 680

ACG GTG AAG CAG AGC TCC GTG GAT ATC TAC TTC CGG CGC CAG GTG GAG          2355
Thr Val Lys Gln Ser Ser Val Asp Ile Tyr Phe Arg Arg Gln Val Glu
        685                 690                 695

CTG AGC ACC ATG TAC CGG CAT ATG GAG AAG CAC AAC TAC GAG AGT GCG          2403
Leu Ser Thr Met Tyr Arg His Met Glu Lys His Asn Tyr Glu Ser Ala
    700                 705                 710

GCG GAG GCC ATC CAG GCC GTG AGA GAC AAC AAG CTG CAT GCC TTC ATC          2451
Ala Glu Ala Ile Gln Ala Val Arg Asp Asn Lys Leu His Ala Phe Ile
715                 720                 725                 730

TGG GAC TCG GCG GTG CTG GAG TTC GAG GCC TCG CAG AAG TGC GAC CTG          2499
Trp Asp Ser Ala Val Leu Glu Phe Glu Ala Ser Gln Lys Cys Asp Leu
                735                 740                 745

GTG ACG ACT GGA GAG CTG TTT TTC CGC TCG GGC TTC GGC ATA GGC ATG          2547
Val Thr Thr Gly Glu Leu Phe Phe Arg Ser Gly Phe Gly Ile Gly Met
            750                 755                 760
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CGC AAA GAC AGC CCC TGG AAG CAG AAC GTC TCC CTG TCC ATC CTC AAG      2595
Arg Lys Asp Ser Pro Trp Lys Gln Asn Val Ser Leu Ser Ile Leu Lys
        765                 770                 775

TCC CAC GAG AAT GGC TTC ATG GAA GAC CTG GAC AAG ACG TGG GTT CGG      2643
Ser His Glu Asn Gly Phe Met Glu Asp Leu Asp Lys Thr Trp Val Arg
    780                 785                 790

TAT CAG GAA TGT GAC TCG CGC AGC AAC GCC CCT GCG ACC CTT ACT TTT      2691
Tyr Gln Glu Cys Asp Ser Arg Ser Asn Ala Pro Ala Thr Leu Thr Phe
795                 800                 805                 810

GAG AAC ATG GCC GGG GTC TTC ATG CTG GTA GCT GGG GGC ATC GTG GCC      2739
Glu Asn Met Ala Gly Val Phe Met Leu Val Ala Gly Gly Ile Val Ala
                815                 820                 825

GGG ATC TTC CTG ATT TTC ATC GAG ATT GCC TAC AAG CGG CAC AAG GAT      2787
Gly Ile Phe Leu Ile Phe Ile Glu Ile Ala Tyr Lys Arg His Lys Asp
            830                 835                 840

GCT CGC CGG AAG CAG ATG CAG CTG GCC TTT GCC GCC GTT AAC GTG TGG      2835
Ala Arg Arg Lys Gln Met Gln Leu Ala Phe Ala Ala Val Asn Val Trp
        845                 850                 855

CGG AAG AAC CTG CAG GAT AGA AAG AGT GGT AGA GCA GAG CCT GAC CCT      2883
Arg Lys Asn Leu Gln Asp Arg Lys Ser Gly Arg Ala Glu Pro Asp Pro
    860                 865                 870

AAA AAG AAA GCC ACA TTT AGG GCT ATC ACC TCC ACC CTG GCT TCC AGC      2931
Lys Lys Lys Ala Thr Phe Arg Ala Ile Thr Ser Thr Leu Ala Ser Ser
875                 880                 885                 890

TTC AAG AGG CGT AGG TCC TCC AAA GAC ACG AGC ACC GGG GGT GGA CGC      2979
Phe Lys Arg Arg Arg Ser Ser Lys Asp Thr Ser Thr Gly Gly Gly Arg
                895                 900                 905

GGT GCT TTG CAA AAC CAA AAA GAC ACA GTG CTG CCG CGA CGC GCT ATT      3027
Gly Ala Leu Gln Asn Gln Lys Asp Thr Val Leu Pro Arg Arg Ala Ile
            910                 915                 920

GAG AGG GAG GAG GGC CAG CTG CAG CTG TGT TCC CGT CAT AGG GAG AGC      3075
Glu Arg Glu Glu Gly Gln Leu Gln Leu Cys Ser Arg His Arg Glu Ser
        925                 930                 935

TGAGACTCCC CGCCCGCCCT CCTCTGCCCC CTCCCCCGCA GACAGACAGA CAGACGGACG    3135

GGACAGCGGC CCGGCCCACG CAGAGCCCCG GAGCACCACG GGGTCGGGGG AGGAGCACCC    3195

CCAGCCTCCC CCAGGCTGCG CCTGCCCGCC CGCCGGTTGG CCGGCTGGCC GGTCCACCCC    3255

GTCCCGGCCC CGCGCGTGCC CCCAGCGTGG GGCTAACGGG CGCCTTGTCT GTGTATTTCT    3315

ATTTTGCAGC AGTACCATCC CACTGATATC ACGGGCCCGC TCAACCTCTC AGATCCCTCG    3375

GTCAGCACCG TGGTGTGAGG CCCCCGGAGG CGCCCACCTG CCCAGTTAGC CCGGCCAAGG    3435

ACACTGATGG GTCCTGCTGC TCGGGAAGGC CTGAGGGAAG CCCACCCGCC CCAGAGACTG    3495

CCCACCCTGG GCCTCCCGTC CGTCCGCCCG CCCACCCCGC TGCCTGGCGG GCAGCCCCTG    3555

CTGGACCAAG GTGCGGACCG GAGCGGCTGA GGACGGGGCA GAGCTGAGTC GGCTGGGCAG    3615

GGCCGCAGGG CGCTCCGGCA GAGGCAGGCC CCTGGGGTCT CTGAGCAGTG GGGAGCGGGG    3675

GCTAACTGCC CCCAGGCGGA GGGGCTTGGA GCAGAGACGG CAGCCCCATC CTTCCCGCAG    3735

CACCAGCCTG AGCCACAGTG GGGCCCATGG CCCCAGCTGG CTGGGTCGCC CCTCCTCGGG    3795
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CGCCTGCGCT CCTCTGCAGC CTGAGCTCCA CCCTCCCCTC TTCTTGCGGC ACCGCCCACC 3855

AAACACCCCG TCTGCCCCTT GACGCCACAC GCCGGGGCTG GCGCTGCCCT CCCCCACGGC 3915

CGTCCCTGAC TTCCCAGCTG GCAGCGCCTC CCGCCGCCTC GGGCCGCCTC CTCCAGAATC 3975

GAGAGGGCTG AGCCCCTCCT CTCCTCGTCC GGCCTGCAGC ACAGAAGGGG GCCTCCCCGG 4035

GGGTCCCCGG ACGCTGGCTC GGGACTGTCT TCAACCCTGC CCTGCACCTT GGGCACGGGA 4095

GAGCGCCACC CGCCCGCCCC CGCCCTCGCT CCGGGTGCGT GACCGGCCCG CCACCTTGTA 4155

CAGAACCAGC ACTCCCAGGG CCCGAGCGCG TGCCTTCCCC GTGCGCAGCC GCGCTCTGCC 4215

CCTCCGTCCC CAGGGTGCAG GCGCGCACCG CCCAACCCCC ACCTCCCGGT GTATGCAGTG 4275

GTGATGCCTA AAGGAATGTC ACG 4298

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 938 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

Met Ser Thr Met Arg Leu Leu Thr Leu Ala Leu Leu Phe Ser Cys Ser
1 5 10 15

Val Ala Arg Ala Ala Cys Asp Pro Lys Ile Val Asn Ile Gly Ala Val
20 25 30

Leu Ser Thr Arg Lys His Glu Gln Met Phe Arg Glu Ala Val Asn Gln
35 40 45

Ala Asn Lys Arg His Gly Ser Trp Lys Ile Gln Leu Asn Ala Thr Ser
50 55 60

Val Thr His Lys Pro Asn Ala Ile Gln Met Ala Leu Ser Val Cys Glu
65 70 75 80

Asp Leu Ile Ser Ser Gln Val Tyr Ala Ile Leu Val Ser His Pro Pro
85 90 95

Thr Pro Asn Asp His Phe Thr Pro Thr Pro Val Ser Tyr Thr Ala Gly
100 105 110

Phe Tyr Arg Ile Pro Val Leu Gly Leu Thr Thr Arg Met Ser Ile Tyr
115 120 125

Ser Asp Lys Ser Ile His Leu Ser Phe Leu Arg Thr Val Pro Pro Tyr
130 135 140

Ser His Gln Ser Ser Val Trp Phe Glu Met Met Arg Val Tyr Ser Trp
145 150 155 160

Asn His Ile Ile Leu Leu Val Ser Asp Asp His Glu Gly Arg Ala Ala
165 170 175

Gln Lys Arg Leu Glu Thr Leu Leu Glu Glu Arg Glu Ser Lys Ala Glu
180 185 190

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Lys Val Leu Gln Phe Asp Pro Gly Thr Lys Asn Val Thr Ala Leu Leu
        195                 200                 205

Met Glu Ala Lys Glu Leu Glu Ala Arg Val Ile Ile Leu Ser Ala Ser
    210                 215                 220

Glu Asp Asp Ala Ala Thr Val Tyr Arg Ala Ala Ala Met Leu Asn Met
225                 230                 235                 240

GlyThr Gly Ser Gly Tyr Val Trp Leu Val Gly Glu Arg Glu Ile Ser
                245                 250                 255

Asn Ala Leu Arg Tyr Ala Pro Asp Gly Ile Leu Gly Leu Gln Leu Ile
            260                 265                 270

Asn Gly Lys Asn Glu Ser Ala His Ile Ser Asp Ala Val Gly Val Val
        275                 280                 285

Ala Gln Ala Val His Glu Leu Leu Glu Lys Glu Asn Ile Thr Asp Pro
    290                 295                 300

Pro Arg Gly Cys Val Gly Asn Thr Asn Ile Trp Lys Thr Gly Pro Leu
305                 310                 315                 320

Phe Lys Arg Val Leu Met Ser Ser Lys Tyr Ala Asp Gly Val Thr Gly
                325                 330                 335

Arg Val Glu Phe Asn Glu Asp Gly Asp Arg Lys Phe Ala Asn Tyr Ser
            340                 345                 350

Ile Met Asn Leu Gln Asn Arg Lys Leu Val Gln Val Gly Ile Tyr Asn
        355                 360                 365

Gly Thr His Val Ile Pro Asn Asp Arg Lys Ile Ile Trp Pro Gly Gly
    370                 375                 380

Glu Thr Glu Lys Pro Arg Gly Tyr Gln Met Ser Thr Arg Leu Lys Ile
385                 390                 395                 400

Val Thr Ile His Gln Glu Pro Phe Val Tyr Val Lys Pro Thr Leu Ser
                405                 410                 415

Asp Gly Thr Cys Lys Glu Glu Phe Thr Val Asn Gly Asp Pro Val Lys
            420                 425                 430

Lys Val Ile Cys Thr Gly Pro Asn Asp Thr Ser Pro Gly Ser Pro Arg
        435                 440                 445

His Thr Val Pro Gln Cys Cys Tyr Gly Phe Cys Ile Asp Leu Leu Ile
    450                 455                 460

Lys Leu Ala Arg Thr Met Asn Phe Thr Tyr Glu Val His Leu Val Ala
465                 470                 475                 480

Asp Gly Lys Phe Gly Thr Gln Glu Arg Val Asn Asn Ser Asn Lys Lys
                485                 490                 495

Glu Trp Asn Gly Met Met Gly Glu Leu Leu Ser Gly Gln Ala Asp Met
            500                 505                 510

Ile Val Ala Pro Leu Thr Ile Asn Asn Glu Arg Ala Gln Tyr Ile Glu
        515                 520                 525

Phe Ser Lys Pro Phe Lys Tyr Gln Gly Leu Thr Ile Leu Val Lys Lys
    530                 535                 540
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Glu Ile Pro Arg Ser Thr Leu Asp Ser Phe Met Gln Pro Phe Gln Ser
545 550 555 560

Thr Leu Trp Leu Leu Val Gly Leu Ser Val His Val Val Ala Val Met
565 570 575

Leu Tyr Leu Leu Asp Arg Phe Ser Pro Phe Gly Arg Phe Lys Val Asn
580 585 590

Ser Glu Glu Glu Glu Glu Asp Ala Leu Thr Leu Ser Ser Ala Met Trp
595 600 605

Phe Ser Trp Gly Val Leu Leu Asn Ser Gly Ile Gly Glu Gly Ala Pro
610 615 620

Arg Ser Phe Ser Ala Arg Ile Leu Gly Met Val Trp Ala Gly Phe Ala
625 630 635 640

Met Ile Ile Val Ala Ser Tyr Thr Ala Asn Leu Ala Ala Phe Leu Val
645 650 655

Leu Asp Arg Pro Glu Glu Arg Ile Thr Gly Ile Asn Asp Pro Arg Leu
660 665 670

Arg Asn Pro Ser Asp Lys Phe Ile Tyr Ala Thr Val Lys Gln Ser Ser
675 680 685

Val Asp Ile Tyr Phe Arg Arg Gln Val Glu Leu Ser Thr Met Tyr Arg
690 695 700

His Met Glu Lys His Asn Tyr Glu Ser Ala Ala Glu Ala Ile Gln Ala
705 710 715 720

Val Arg Asp Asn Lys Leu His Ala Phe Ile Trp Asp Ser Ala Val Leu
725 730 735

Glu Phe Glu Ala Ser Gln Lys Cys Asp Leu Val Thr Thr Gly Glu Leu
740 745 750

Phe Phe Arg Ser Gly Phe Gly Ile Gly Met Arg Lys Asp Ser Pro Trp
755 760 765

Lys Gln Asn Val Ser Leu Ser Ile Leu Lys Ser His Glu Asn Gly Phe
770 775 780

Met Glu Asp Leu Asp Lys Thr Trp Val Arg Tyr Gln Glu Cys Asp Ser
785 790 795 800

Arg Ser Asn Ala Pro Ala Thr Leu Thr Phe Glu Asn Met Ala Gly Val
805 810 815

Phe Met Leu Val Ala Gly Gly Ile Val Ala Gly Ile Phe Leu Ile Phe
820 825 830

Ile Glu Ile Ala Tyr Lys Arg His Lys Asp Ala Arg Arg Lys Gln Met
835 840 845

Gln Leu Ala Phe Ala Ala Val Asn Val Trp Arg Lys Asn Leu Gln Asp
850 855 860

Arg Lys Ser Gly Arg Ala Glu Pro Asp Pro Lys Lys Lys Ala Thr Phe
865 870 875 880

Arg Ala Ile Thr Ser Thr Leu Ala Ser Ser Phe Lys Arg Arg Arg Ser
885 890 895

```
Ser Lys Asp Thr Ser Thr Gly Gly Gly Arg Gly Ala Leu Gln Asn Gln
            900                 905                 910

Lys Asp Thr Val Leu Pro Arg Arg Ala Ile Glu Arg Glu Glu Gly Gln
        915                 920                 925

Leu Gln Leu Cys Ser Arg His Arg Glu Ser
    930                 935
```

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 63 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 1..63

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

```
AGT AAA AAA AGG AAC TAT GAA AAC CTC GAC CAA CTG TCC TAT GAC AAC        48
Ser Lys Lys Arg Asn Tyr Glu Asn Leu Asp Gln Leu Ser Tyr Asp Asn
  1               5                  10                  15

AAG CGC GGA CCC AAG                                                  63
Lys Arg Gly Pro Lys
            20
```

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 21 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

```
Ser Lys Lys Arg Asn Tyr Glu Asn Leu Asp Gln Leu Ser Tyr Asp Asn
  1               5                  10                  15

Lys Arg Gly Pro Lys
            20
```

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 4340 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 189..3899

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

```
CCCTTAATAA GATTTGCCAC GTACACTCGA GCCATCGCGA GTGTCCTTGA GCCGCGGGTG      60

ACGGTGGCTC TCGCTGCTCG CGCCCCCTCC TCCCGCGGGG GGAGCCTGAT GCCACGTTCC     120

CTATGAATTA TTTATCGCCG GCCTAAAAAT ACCCCGAACT TCACAGCCCG AGTGACCCTC     180

CGGTGGAC ATG GGT GGG GCC CTG GGG CCG GCC CTG TTG CTC ACC TCG CTC       230
         Met Gly Gly Ala Leu Gly Pro Ala Leu Leu Leu Thr Ser Leu
           1               5                  10

TTC GGT GCC TGG GCA GGG CTG GGT CCG GGG CAG GGC GAG CAG GGC ATG       278
Phe Gly Ala Trp Ala Gly Leu Gly Pro Gly Gln Gly Glu Gln Gly Met
 15                  20                  25                  30

ACG GTG GCC GTG GTG TTT AGC AGC TCA GGG CCG CCC CAG GCC CAG TTC       326
Thr Val Ala Val Val Phe Ser Ser Ser Gly Pro Pro Gln Ala Gln Phe
                 35                  40                  45

CGT GTC CGC CTC ACC CCC CAG AGC TTC CTG GAC CTA CCC CTG GAG ATC       374
Arg Val Arg Leu Thr Pro Gln Ser Phe Leu Asp Leu Pro Leu Glu Ile
             50                  55                  60

CAG CCG CTC ACA GTT GGG GTC AAC ACC ACC AAC CCC AGC AGC CTC CTC       422
Gln Pro Leu Thr Val Gly Val Asn Thr Thr Asn Pro Ser Ser Leu Leu
         65                  70                  75

ACC CAG ATC TGC GGC CTC CTG GGT GCT GCC CAC GTC CAC GGC ATT GTC       470
Thr Gln Ile Cys Gly Leu Leu Gly Ala Ala His Val His Gly Ile Val
     80                  85                  90

TTT GAG GAC AAC GTG GAC ACC GAG GCG GTG GCC CAG ATC CTT GAC TTC       518
Phe Glu Asp Asn Val Asp Thr Glu Ala Val Ala Gln Ile Leu Asp Phe
 95                  100                 105                 110

ATC TCC TCC CAG ACC CAT GTG CCC ATC CTC AGC ATC AGC GGA GGC TCT       566
Ile Ser Ser Gln Thr His Val Pro Ile Leu Ser Ile Ser Gly Gly Ser
                115                 120                 125

GCT GTG GTC CTC ACC CCC AAG GAG CCG GGC TCC GCC TTC CTG CAG CTG       614
Ala Val Val Leu Thr Pro Lys Glu Pro Gly Ser Ala Phe Leu Gln Leu
            130                 135                 140

GGC GTG TCC CTG GAG CAG CAG CTG CAG GTG CTG TTC AAG GTG CTG GAA       662
Gly Val Ser Leu Glu Gln Gln Leu Gln Val Leu Phe Lys Val Leu Glu
        145                 150                 155

GAG TAC GAC TGG AGC GCC TTC GCC GTC ATC ACC AGC CTG CAC CCG GGC       710
Glu Tyr Asp Trp Ser Ala Phe Ala Val Ile Thr Ser Leu His Pro Gly
    160                 165                 170

CAC GCG CTC TTC CTG GAG GGC GTG CGC GCC GTC GCC GAC GCC AGC CAC       758
His Ala Leu Phe Leu Glu Gly Val Arg Ala Val Ala Asp Ala Ser His
175                 180                 185                 190

GTG AGT TGG CGG CTG CTG GAC GTG GTC ACG CTG GAA CTG GAC CCG GGA       806
Val Ser Trp Arg Leu Leu Asp Val Val Thr Leu Glu Leu Asp Pro Gly
                195                 200                 205
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GGG CCG CGC GCG CGC ACG CAG CGC CTG CTG CGC CAG CTC GAC GCG CCC          854
Gly Pro Arg Ala Arg Thr Gln Arg Leu Leu Arg Gln Leu Asp Ala Pro
            210                 215                 220

GTG TTT GTG GCC TAC TGC TCG CGC GAG GAG GCC GAG GTG CTC TTC GCC          902
Val Phe Val Ala Tyr Cys Ser Arg Glu Glu Ala Glu Val Leu Phe Ala
        225                 230                 235

GAG GCG GCG CAG GCC GGT CTG GTG GGG CCC GGC CAC GTG TGG CTG GTG          950
Glu Ala Ala Gln Ala Gly Leu Val Gly Pro Gly His Val Trp Leu Val
    240                 245                 250

CCC AAC CTG GCG CTG GGC AGC ACC GAT GCG CCC CCC GCC ACC TTC CCC          998
Pro Asn Leu Ala Leu Gly Ser Thr Asp Ala Pro Pro Ala Thr Phe Pro
255                 260                 265                 270

GTG GGC CTC ATC AGC GTC GTC ACC GAG AGC TGG CGC CTC AGC CTG CGC         1046
Val Gly Leu Ile Ser Val Val Thr Glu Ser Trp Arg Leu Ser Leu Arg
                275                 280                 285

CAG AAG GTG CGC GAC GGC GTG GCC ATT CTG GCC CTG GGC GCC CAC AGC         1094
Gln Lys Val Arg Asp Gly Val Ala Ile Leu Ala Leu Gly Ala His Ser
            290                 295                 300

TAC TGG CGC CAG CAT GGA ACC CTG CCA GCC CCG GCC GGG GAC TGC CGT         1142
Tyr Trp Arg Gln His Gly Thr Leu Pro Ala Pro Ala Gly Asp Cys Arg
        305                 310                 315

GTT CAC CCT GGG CCC GTC AGC CCT GCC CGG GAG GCC TTC TAC AGG CAC         1190
Val His Pro Gly Pro Val Ser Pro Ala Arg Glu Ala Phe Tyr Arg His
    320                 325                 330

CTA CTG AAT GTC ACC TGG GAG GGC CGA GAC TTC TCC TTC AGC CCT GGT         1238
Leu Leu Asn Val Thr Trp Glu Gly Arg Asp Phe Ser Phe Ser Pro Gly
335                 340                 345                 350

GGG TAC CTG GTC CAG CCC ACC ATG GTG GTG ATC GCC CTC AAC CGG CAC         1286
Gly Tyr Leu Val Gln Pro Thr Met Val Val Ile Ala Leu Asn Arg His
                355                 360                 365

CGC CTC TGG GAG ATG GTG GGG CGC TGG GAG CAT GGC GTC CTA TAC ATG         1334
Arg Leu Trp Glu Met Val Gly Arg Trp Glu His Gly Val Leu Tyr Met
            370                 375                 380

AAG TAC CCC GTG TGG CCT CGC TAC AGT GCC TCT CTG CAG CCT GTG GTG         1382
Lys Tyr Pro Val Trp Pro Arg Tyr Ser Ala Ser Leu Gln Pro Val Val
        385                 390                 395

GAC AGT CGG CAC CTG ACG GTG GCC ACG CTG GAA GAG CGG CCC TTT GTC         1430
Asp Ser Arg His Leu Thr Val Ala Thr Leu Glu Glu Arg Pro Phe Val
    400                 405                 410

ATC GTG GAG AGC CCT GAC CCT GGC ACA GGA GGC TGT GTC CCC AAC ACC         1478
Ile Val Glu Ser Pro Asp Pro Gly Thr Gly Gly Cys Val Pro Asn Thr
415                 420                 425                 430

GTG CCC TGC CGC AGG CAG AGC AAC CAC ACC TTC AGC AGC GGG GAC GTG         1526
Val Pro Cys Arg Arg Gln Ser Asn His Thr Phe Ser Ser Gly Asp Val
                435                 440                 445

GCC CCC TAC ACC AAG CTC TGC TGT AAG GGA TTC TGC ATC GAC ATC CTC         1574
Ala Pro Tyr Thr Lys Leu Cys Cys Lys Gly Phe Cys Ile Asp Ile Leu
            450                 455                 460

AAG AAG CTG GCC AGA GTG GTC AAA TTC TCC TAC GAC CTG TAC CTG GTG         1622
Lys Lys Leu Ala Arg Val Val Lys Phe Ser Tyr Asp Leu Tyr Leu Val
        465                 470                 475
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ACC AAC GGC AAG CAT GGC AAG CGG GTG CGC GGC GTA TGG AAC GGC ATG      1670
Thr Asn Gly Lys His Gly Lys Arg Val Arg Gly Val Trp Asn Gly Met
    480                 485                 490

ATT GGG GAG GTG TAC TAC AAG CGG GCA GAC ATG GCC ATC GGC TCC CTC      1718
Ile Gly Glu Val Tyr Tyr Lys Arg Ala Asp Met Ala Ile Gly Ser Leu
495                 500                 505                 510

ACC ATC AAT GAG GAA CGC TCC GAG ATC GTA GAC TTC TCT GTA CCC TTT      1766
Thr Ile Asn Glu Glu Arg Ser Glu Ile Val Asp Phe Ser Val Pro Phe
                515                 520                 525

GTG GAG ACG GGC ATC AGT GTG ATG GTG GCT CGC AGC AAT GGC ACC GTC      1814
Val Glu Thr Gly Ile Ser Val Met Val Ala Arg Ser Asn Gly Thr Val
            530                 535                 540

TCC CCC TCG GCC TTC TTG GAG CCA TAT AGC CCT GCA GTG TGG GTG ATG      1862
Ser Pro Ser Ala Phe Leu Glu Pro Tyr Ser Pro Ala Val Trp Val Met
        545                 550                 555

ATG TTT GTC ATG TGC CTC ACT GTG GTG GCC ATC ACC GTC TTC ATG TTC      1910
Met Phe Val Met Cys Leu Thr Val Val Ala Ile Thr Val Phe Met Phe
    560                 565                 570

GAG TAC TTC AGC CCT GTC AGC TAC AAC CAG AAC CTC ACC AGA GGC AAG      1958
Glu Tyr Phe Ser Pro Val Ser Tyr Asn Gln Asn Leu Thr Arg Gly Lys
575                 580                 585                 590

AAG TCC GGG GGC CCA GCT TTC ACT ATC GGC AAG TCC GTG TGG CTG CTG      2006
Lys Ser Gly Gly Pro Ala Phe Thr Ile Gly Lys Ser Val Trp Leu Leu
                595                 600                 605

TGG GCG CTG GTC TTC AAC AAC TCA GTG CCC ATC GAG AAC CCG CGG GGC      2054
Trp Ala Leu Val Phe Asn Asn Ser Val Pro Ile Glu Asn Pro Arg Gly
            610                 615                 620

ACC ACC AGC AAG ATC ATG GTT CTG GTC TGG GCC TTC TTT GCT GTC ATC      2102
Thr Thr Ser Lys Ile Met Val Leu Val Trp Ala Phe Phe Ala Val Ile
        625                 630                 635

TTC CTC GCC AGA TAC ACG GCC AAC CTG GCC GCC TTC ATG ATC CAA GAG      2150
Phe Leu Ala Arg Tyr Thr Ala Asn Leu Ala Ala Phe Met Ile Gln Glu
    640                 645                 650

CAA TAC ATC GAC ACT GTG TCG GGC CTC AGT GAC AAG AAG TTT CAG CGG      2198
Gln Tyr Ile Asp Thr Val Ser Gly Leu Ser Asp Lys Lys Phe Gln Arg
655                 660                 665                 670

CCT CAA GAT CAG TAC CCA CCT TTC CGC TTC GGC ACG GTG CCC AAC GGC      2246
Pro Gln Asp Gln Tyr Pro Pro Phe Arg Phe Gly Thr Val Pro Asn Gly
                675                 680                 685

AGC ACG GAG CGG AAC ATC CGC AGT AAC TAC CGT GAC ATG CAC ACC CAC      2294
Ser Thr Glu Arg Asn Ile Arg Ser Asn Tyr Arg Asp Met His Thr His
            690                 695                 700

ATG GTC AAG TTC AAC CAG CGC TCG GTG GAG GAC GCG CTC ACC AGC CTC      2342
Met Val Lys Phe Asn Gln Arg Ser Val Glu Asp Ala Leu Thr Ser Leu
        705                 710                 715

AAG ATG GGG AAG CTG GAT GCC TTC ATC TAT GAT GCT GCT GTC CTC AAC      2390
Lys Met Gly Lys Leu Asp Ala Phe Ile Tyr Asp Ala Ala Val Leu Asn
    720                 725                 730

TAC ATG GCA GGC AAG GAC GAG GGC TGC AAG CTG GTC ACC ATT GGG TCT      2438
Tyr Met Ala Gly Lys Asp Glu Gly Cys Lys Leu Val Thr Ile Gly Ser
735                 740                 745                 750
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GGC AAG GTC TTT GCT ACC ACT GGC TAC GGC ATC GCC ATG CAG AAG GAC      2486
Gly Lys Val Phe Ala Thr Thr Gly Tyr Gly Ile Ala Met Gln Lys Asp
                755                 760                 765

TCC CAC TGG AAG CGG GCC ATA GAC CTG GCG CTC TTG CAG TTC CTG GGG      2534
Ser His Trp Lys Arg Ala Ile Asp Leu Ala Leu Leu Gln Phe Leu Gly
            770                 775                 780

GAC GGA GAG ACA CAG AAA CTG GAG ACA GTG TGG CTC TCA GGG ATC TGC      2582
Asp Gly Glu Thr Gln Lys Leu Glu Thr Val Trp Leu Ser Gly Ile Cys
        785                 790                 795

CAG AAT GAG AAG AAC GAG GTG ATG AGC AGC AAG CTG GAC ATC GAC AAC      2630
Gln Asn Glu Lys Asn Glu Val Met Ser Ser Lys Leu Asp Ile Asp Asn
    800                 805                 810

ATG GCA GGC GTC TTC TAC ATG CTG CTG GTG GCC ATG GGG CTG GCC CTG      2678
Met Ala Gly Val Phe Tyr Met Leu Leu Val Ala Met Gly Leu Ala Leu
815                 820                 825                 830

CTG GTC TTC GCC TGG GAG CAC CTG GTC TAC TGG AAG CTG CGC CAC TCG      2726
Leu Val Phe Ala Trp Glu His Leu Val Tyr Trp Lys Leu Arg His Ser
                835                 840                 845

GTG CCC AAC TCA TCC CAG CTG GAC TTC CTG CTG GCT TTC AGC AGG GGC      2774
Val Pro Asn Ser Ser Gln Leu Asp Phe Leu Leu Ala Phe Ser Arg Gly
            850                 855                 860

ATC TAC AGC TGC TTC AGC GGG GTG CAG AGC CTC GCC AGC CCA CCG CGG      2822
Ile Tyr Ser Cys Phe Ser Gly Val Gln Ser Leu Ala Ser Pro Pro Arg
        865                 870                 875

CAG GCC AGC CCG GAC CTC ACG GCC AGC TCG GCC CAG GCC AGC GTG CTC      2870
Gln Ala Ser Pro Asp Leu Thr Ala Ser Ser Ala Gln Ala Ser Val Leu
    880                 885                 890

AAG ATG CTG CAG GCA GCC CGC GAC ATG GTG ACC ACG GCG GGC GTA AGC      2918
Lys Met Leu Gln Ala Ala Arg Asp Met Val Thr Thr Ala Gly Val Ser
895                 900                 905                 910

AGC TCC CTG GAC CGC GCC ACT CGC ACC ATC GAG AAT TGG GGT GGC GGC      2966
Ser Ser Leu Asp Arg Ala Thr Arg Thr Ile Glu Asn Trp Gly Gly Gly
                915                 920                 925

CGC CGT GCG CCC CCA CCG TCC CCC TGC CCG ACC CCG CGG TCT GGC CCC      3014
Arg Arg Ala Pro Pro Pro Ser Pro Cys Pro Thr Pro Arg Ser Gly Pro
            930                 935                 940

AGC CCA TGC CTG CCC ACC CCC GAC CCG CCC CCA GAG CCG AGC CCC ACG      3062
Ser Pro Cys Leu Pro Thr Pro Asp Pro Pro Pro Glu Pro Ser Pro Thr
        945                 950                 955

GGC TGG GGA CCG CCA GAC GGG GGT CGC GCG GCG CTT GTG CGC AGG GCT      3110
Gly Trp Gly Pro Pro Asp Gly Gly Arg Ala Ala Leu Val Arg Arg Ala
    960                 965                 970

CCG CAG CCC CCG GGC CGC CCC CCG ACG CCG GGG CCG CCC CTG TCC GAC      3158
Pro Gln Pro Pro Gly Arg Pro Pro Thr Pro Gly Pro Pro Leu Ser Asp
975                 980                 985                 990

GTC TCC CGA GTG TCG CGC CGC CCA GCC TGG GAG GCG CGG TGG CCG GTG      3206
Val Ser Arg Val Ser Arg Arg Pro Ala Trp Glu Ala Arg Trp Pro Val
                995                 1000                1005

CGG ACC GGG CAC TGC GGG AGG CAC CTC TCG GCC TCC GAG CGG CCC CTG      3254
Arg Thr Gly His Cys Gly Arg His Leu Ser Ala Ser Glu Arg Pro Leu
            1010                1015                1020
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TCG CCC GCG CGC TGT CAC TAC AGC TCC TTT CCT CGA GCC GAC CGA TCC      3302
Ser Pro Ala Arg Cys His Tyr Ser Ser Phe Pro Arg Ala Asp Arg Ser
        1025                1030                1035

GGC CGC CCC TTC CTC CCG CTC TTC CCG GAG CCC CCG GAG CTG GAG GAC      3350
Gly Arg Pro Phe Leu Pro Leu Phe Pro Glu Pro Pro Glu Leu Glu Asp
    1040                1045                1050

CTG CCG CTG CTC GGT CCG GAG CAG CTG GCC CGG CGG GAG GCC CTG CTG      3398
Leu Pro Leu Leu Gly Pro Glu Gln Leu Ala Arg Arg Glu Ala Leu Leu
1055                1060                1065                1070

CAC GCG GCC TGG GCC CGG GGC TCG CGC CCG CGT CAC GCT TCC CTG CCC      3446
His Ala Ala Trp Ala Arg Gly Ser Arg Pro Arg His Ala Ser Leu Pro
                1075                1080                1085

AGC TCC GTG GCC GAG GCC TTC GCT CGG CCC AGC TCG CTG CCC GCT GGG      3494
Ser Ser Val Ala Glu Ala Phe Ala Arg Pro Ser Ser Leu Pro Ala Gly
            1090                1095                1100

TGC ACC GGC CCC GCC TGC GCC CGC CCC GAC GGA CAC TCG GCC TGC AGG      3542
Cys Thr Gly Pro Ala Cys Ala Arg Pro Asp Gly His Ser Ala Cys Arg
        1105                1110                1115

CGC TTG GCG CAG GCG CAG TCG ATG TGC TTG CCG ATC TAC CGG GAG GCC      3590
Arg Leu Ala Gln Ala Gln Ser Met Cys Leu Pro Ile Tyr Arg Glu Ala
    1120                1125                1130

TGC CAG GAG GGC GAG CAG GCA GGG GCC CCC GCC TGG CAG CAC AGA CAG      3638
Cys Gln Glu Gly Glu Gln Ala Gly Ala Pro Ala Trp Gln His Arg Gln
1135                1140                1145                1150

CAC GTC TGC CTG CAC GCC CAC GCC CAC CTG CCA TTT TGC TGG GGG GCT      3686
His Val Cys Leu His Ala His Ala His Leu Pro Phe Cys Trp Gly Ala
                1155                1160                1165

GTC TGT CCT CAC CTT CCA CCC TGT GCC AGC CAC GGC TCC TGG CTC TCC      3734
Val Cys Pro His Leu Pro Pro Cys Ala Ser His Gly Ser Trp Leu Ser
            1170                1175                1180

GGG GCC TGG GGG CCT CTG GGG CAC AGG GGC AGG ACT CTG GGG CTG GGC      3782
Gly Ala Trp Gly Pro Leu Gly His Arg Gly Arg Thr Leu Gly Leu Gly
        1185                1190                1195

ACA GGC TAC AGA GAC AGT GGG GGA CTG GAC GAG ATC AGC AGG GTA GCC      3830
Thr Gly Tyr Arg Asp Ser Gly Gly Leu Asp Glu Ile Ser Arg Val Ala
    1200                1205                1210

CGT GGG ACG CAA GGC TTC CCG GGA CCC TGC ACC TGG AGA CGG ATC TCC      3878
Arg Gly Thr Gln Gly Phe Pro Gly Pro Cys Thr Trp Arg Arg Ile Ser
1215                1220                1225                1230

AGT CTG GAG TCA GAA GTG TGAGTTATCA GCCACTCAGG CTCCGAGCCA             3926
Ser Leu Glu Ser Glu Val
                1235

GCTGGATTCT CTGCCTGCCA CTGTCAGGGT TAAGCGGCAG GCAGGATTGG GCTTTTCTGG    3986

CTTCTACCAT GAAATCCTGG CCATGGGACC CCAGTGACAG ATGATGTCTT CCATGGTCAT    4046

CAGTGACCTC AGTAGCCTCA AATCATGGTG AGGGCTGGGC TTTTGCTGTC CTCTTCTCAC    4106

GCAGAGTTCT GCCAGGAGGG TGTGCTGTGG GGGTCAGACT CCTGAGGCTC TCCCTTCCCT    4166

GGGGCTAGCC AGTTACTGGT CATGCCTGCT GTGGGCATGG AGGCTGGAAC TTGTGGTTGA    4226
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GGCAGGGCCA TCCCGATCCT TGCTCTACCT GGCTAGAGTT TCTTCTCATC AGAGCACTGG 4286

GACATTAAAC CCACCTTTTC CCAGAAAAAA AAAAAAAAAA AAAAAAAAAA AAAG 4340

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1236 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

Met Gly Gly Ala Leu Gly Pro Ala Leu Leu Leu Thr Ser Leu Phe Gly
1 5 10 15

Ala Trp Ala Gly Leu Gly Pro Gly Gln Gly Glu Gln Gly Met Thr Val
20 25 30

Ala Val Val Phe Ser Ser Ser Gly Pro Pro Gln Ala Gln Phe Arg Val
35 40 45

Arg Leu Thr Pro Gln Ser Phe Leu Asp Leu Pro Leu Glu Ile Gln Pro
50 55 60

Leu Thr Val Gly Val Asn Thr Thr Asn Pro Ser Ser Leu Leu Thr Gln
65 70 75 80

Ile Cys Gly Leu Leu Gly Ala Ala His Val His Gly Ile Val Phe Glu
85 90 95

Asp Asn Val Asp Thr Glu Ala Val Ala Gln Ile Leu Asp Phe Ile Ser
100 105 110

Ser Gln Thr His Val Pro Ile Leu Ser Ile Ser Gly Gly Ser Ala Val
115 120 125

Val Leu Thr Pro Lys Glu Pro Gly Ser Ala Phe Leu Gln Leu Gly Val
130 135 140

Ser Leu Glu Gln Gln Leu Gln Val Leu Phe Lys Val Leu Glu Glu Tyr
145 150 155 160

Asp Trp Ser Ala Phe Ala Val Ile Thr Ser Leu His Pro Gly His Ala
165 170 175

Leu Phe Leu Glu Gly Val Arg Ala Val Ala Asp Ala Ser His Val Ser
180 185 190

Trp Arg Leu Leu Asp Val Val Thr Leu Glu Leu Asp Pro Gly Gly Pro
195 200 205

Arg Ala Arg Thr Gln Arg Leu Leu Arg Gln Leu Asp Ala Pro Val Phe
210 215 220

Val Ala Tyr Cys Ser Arg Glu Glu Ala Glu Val Leu Phe Ala Glu Ala
225 230 235 240

Ala Gln Ala Gly Leu Val Gly Pro Gly His Val Trp Leu Val Pro Asn
245 250 255

Leu Ala Leu Gly Ser Thr Asp Ala Pro Pro Ala Thr Phe Pro Val Gly
260 265 270

Leu Ile Ser Val Val Thr Glu Ser Trp Arg Leu Ser Leu Arg Gln Lys
275 280 285

Val Arg Asp Gly Val Ala Ile Leu Ala Leu Gly Ala His Ser Tyr Trp
290 295 300

Arg Gln His Gly Thr Leu Pro Ala Pro Ala Gly Asp Cys Arg Val His
305 310 315 320

Pro Gly Pro Val Ser Pro Ala Arg Glu Ala Phe Tyr Arg His Leu Leu
325 330 335

Asn Val Thr Trp Glu Gly Arg Asp Phe Ser Phe Ser Pro Gly Gly Tyr
340 345 350

Leu Val Gln Pro Thr Met Val Val Ile Ala Leu Asn Arg His Arg Leu
355 360 365

Trp Glu Met Val Gly Arg Trp Glu His Gly Val Leu Tyr Met Lys Tyr
370 375 380

Pro Val Trp Pro Arg Tyr Ser Ala Ser Leu Gln Pro Val Val Asp Ser
385 390 395 400

Arg His Leu Thr Val Ala Thr Leu Glu Glu Arg Pro Phe Val Ile Val
405 410 415

Glu Ser Pro Asp Pro Gly Thr Gly Gly Cys Val Pro Asn Thr Val Pro
420 425 430

Cys Arg Arg Gln Ser Asn His Thr Phe Ser Ser Gly Asp Val Ala Pro
435 440 445

Tyr Thr Lys Leu Cys Cys Lys Gly Phe Cys Ile Asp Ile Leu Lys Lys
450 455 460

Leu Ala Arg Val Val Lys Phe Ser Tyr Asp Leu Tyr Leu Val Thr Asn
465 470 475 480

Gly Lys His Gly Lys Arg Val Arg Gly Val Trp Asn Gly Met Ile Gly
485 490 495

Glu Val Tyr Tyr Lys Arg Ala Asp Met Ala Ile Gly Ser Leu Thr Ile
500 505 510

Asn Glu Glu Arg Ser Glu Ile Val Asp Phe Ser Val Pro Phe Val Glu
515 520 525

Thr Gly Ile Ser Val Met Val Ala Arg Ser Asn Gly Thr Val Ser Pro
530 535 540

Ser Ala Phe Leu Glu Pro Tyr Ser Pro Ala Val Trp Val Met Met Phe
545 550 555 560

Val Met Cys Leu Thr Val Val Ala Ile Thr Val Phe Met Phe Glu Tyr
565 570 575

Phe Ser Pro Val Ser Tyr Asn Gln Asn Leu Thr Arg Gly Lys Lys Ser
580 585 590

Gly Gly Pro Ala Phe Thr Ile Gly Lys Ser Val Trp Leu Leu Trp Ala
595 600 605

Leu Val Phe Asn Asn Ser Val Pro Ile Glu Asn Pro Arg Gly Thr Thr
610 615 620

Ser Lys Ile Met Val Leu Val Trp Ala Phe Phe Ala Val Ile Phe Leu
625 630 635 640

Ala Arg Tyr Thr Ala Asn Leu Ala Ala Phe Met Ile Gln Glu Gln Tyr
645 650 655

Ile Asp Thr Val Ser Gly Leu Ser Asp Lys Lys Phe Gln Arg Pro Gln
660 665 670

Asp Gln Tyr Pro Pro Phe Arg Phe Gly Thr Val Pro Asn Gly Ser Thr
675 680 685

Glu Arg Asn Ile Arg Ser Asn Tyr Arg Asp Met His Thr His Met Val
690 695 700

Lys Phe Asn Gln Arg Ser Val Glu Asp Ala Leu Thr Ser Leu Lys Met
705 710 715 720

Gly Lys Leu Asp Ala Phe Ile Tyr Asp Ala Ala Val Leu Asn Tyr Met
725 730 735

Ala Gly Lys Asp Glu Gly Cys Lys Leu Val Thr Ile Gly Ser Gly Lys
740 745 750

Val Phe Ala Thr Thr Gly Tyr Gly Ile Ala Met Gln Lys Asp Ser His
755 760 765

Trp Lys Arg Ala Ile Asp Leu Ala Leu Leu Gln Phe Leu Gly Asp Gly
770 775 780

Glu Thr Gln Lys Leu Glu Thr Val Trp Leu Ser Gly Ile Cys Gln Asn
785 790 795 800

Glu Lys Asn Glu Val Met Ser Ser Lys Leu Asp Ile Asp Asn Met Ala
805 810 815

Gly Val Phe Tyr Met Leu Leu Val Ala Met Gly Leu Ala Leu Leu Val
820 825 830

Phe Ala Trp Glu His Leu Val Tyr Trp Lys Leu Arg His Ser Val Pro
835 840 845

Asn Ser Ser Gln Leu Asp Phe Leu Leu Ala Phe Ser Arg Gly Ile Tyr
850 855 860

Ser Cys Phe Ser Gly Val Gln Ser Leu Ala Ser Pro Pro Arg Gln Ala
865 870 875 880

Ser Pro Asp Leu Thr Ala Ser Ser Ala Gln Ala Ser Val Leu Lys Met
885 890 895

Leu Gln Ala Ala Arg Asp Met Val Thr Thr Ala Gly Val Ser Ser Ser
900 905 910

Leu Asp Arg Ala Thr Arg Thr Ile Glu Asn Trp Gly Gly Gly Arg Arg
915 920 925

Ala Pro Pro Pro Ser Pro Cys Pro Thr Pro Arg Ser Gly Pro Ser Pro
930 935 940

Cys Leu Pro Thr Pro Asp Pro Pro Pro Glu Pro Ser Pro Thr Gly Trp
945 950 955 960

Gly Pro Pro Asp Gly Gly Arg Ala Ala Leu Val Arg Arg Ala Pro Gln
965 970 975

Pro Pro Gly Arg Pro Pro Thr Pro Gly Pro Pro Leu Ser Asp Val Ser
980 985 990

Arg Val Ser Arg Arg Pro Ala Trp Glu Ala Arg Trp Pro Val Arg Thr
995 1000 1005

Gly His Cys Gly Arg His Leu Ser Ala Ser Glu Arg Pro Leu Ser Pro
1010 1015 1020

Ala Arg Cys His Tyr Ser Ser Phe Pro Arg Ala Asp Arg Ser Gly Arg
1025 1030 1035 1040

Pro Phe Leu Pro Leu Phe Pro Glu Pro Pro Glu Leu Glu Asp Leu Pro
1045 1050 1055

Leu Leu Gly Pro Glu Gln Leu Ala Arg Arg Glu Ala Leu Leu His Ala
1060 1065 1070

Ala Trp Ala Arg Gly Ser Arg Pro Arg His Ala Ser Leu Pro Ser Ser
1075 1080 1085

Val Ala Glu Ala Phe Ala Arg Pro Ser Ser Leu Pro Ala Gly Cys Thr
1090 1095 1100

Gly Pro Ala Cys Ala Arg Pro Asp Gly His Ser Ala Cys Arg Arg Leu
1105 1110 1115 1120

Ala Gln Ala Gln Ser Met Cys Leu Pro Ile Tyr Arg Glu Ala Cys Gln
1125 1130 1135

Glu Gly Glu Gln Ala Gly Ala Pro Ala Trp Gln His Arg Gln His Val
1140 1145 1150

Cys Leu His Ala His Ala His Leu Pro Phe Cys Trp Gly Ala Val Cys
1155 1160 1165

Pro His Leu Pro Pro Cys Ala Ser His Gly Ser Trp Leu Ser Gly Ala
1170 1175 1180

Trp Gly Pro Leu Gly His Arg Gly Arg Thr Leu Gly Leu Gly Thr Gly
1185 1190 1195 1200

Tyr Arg Asp Ser Gly Gly Leu Asp Glu Ile Ser Arg Val Ala Arg Gly
1205 1210 1215

Thr Gln Gly Phe Pro Gly Pro Cys Thr Trp Arg Arg Ile Ser Ser Leu
1220 1225 1230

Glu Ser Glu Val
1235

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 24 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 2..22

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

C TCT GAG GCT CAG CCT GTC CCC AG 24
Ser Glu Ala Gln Pro Val Pro
1 5

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 7 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

Ser Glu Ala Gln Pro Val Pro
1 5

(2) INFORMATION FOR SEQ ID NO:9:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 11 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: unknown
(D) TOPOLOGY: unknown

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

AGAAGGGGGT G 11

(2) INFORMATION FOR SEQ ID NO:10:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 4808 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 311..4705

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

ATCATGGGAC CGGGTGAGCG CTGAGAATCG CGGCCGCAGC CATCAGCCCT GGAGATGACC 60

AGGAGCGGCC ACTGCTGAGA ACTATGTGGA GAGAGGCTGC GAGCCCTGCT GCAGAGCCTC 120

CGGCTGGGAT AGCCGCCCCC CGTGGGGGCG ATGCGGACAG CGCGGGACAG CCAGGGGAGC 180

GCGCTGGGGC CGCAGCATGC GGGAACCCGC TAAACCCGGT GGCTGCTGAG GCGGCCGAGA 240

TGCTCGTGCG CGCAGCGCGC CCCACTGCAT CCTCGACCTT CTCGGGCTAC AGGGACCGTC 300

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AGTGGCGACT ATG GGC AGA GTG GGC TAT TGG ACC CTG CTG GTG CTG CCG                 349
           Met Gly Arg Val Gly Tyr Trp Thr Leu Leu Val Leu Pro
             1               5                  10

GCC CTT CTG GTC TGG CGC GGT CCG GCG CCG AGC GCG GCG GCG GAG AAG               397
Ala Leu Leu Val Trp Arg Gly Pro Ala Pro Ser Ala Ala Ala Glu Lys
     15                  20                  25

GGT CCC CCC GCG CTA AAT ATT GCG GTG ATG CTG GGT CAC AGC CAC GAC               445
Gly Pro Pro Ala Leu Asn Ile Ala Val Met Leu Gly His Ser His Asp
 30                  35                  40                  45

GTG ACA GAG CGC GAA CTT CGA ACA CTG TGG GGC CCC GAG CAG GCG GCG               493
Val Thr Glu Arg Glu Leu Arg Thr Leu Trp Gly Pro Glu Gln Ala Ala
                 50                  55                  60

GGG CTG CCC CTG GAC GTG AAC GTG GTA GCT CTG CTG ATG AAC CGC ACC               541
Gly Leu Pro Leu Asp Val Asn Val Val Ala Leu Leu Met Asn Arg Thr
             65                  70                  75

GAC CCC AAG AGC CTC ATC ACG CAC GTG TGC GAC CTC ATG TCC GGG GCA               589
Asp Pro Lys Ser Leu Ile Thr His Val Cys Asp Leu Met Ser Gly Ala
         80                  85                  90

CGC ATC CAC GGC CTC GTG TTT GGG GAC GAC ACG GAC CAG GAG GCC GTA               637
Arg Ile His Gly Leu Val Phe Gly Asp Asp Thr Asp Gln Glu Ala Val
     95                  100                 105

GCC CAG ATG CTG GAT TTT ATC TCC TCC CAC ACC TTC GTC CCC ATC TTG               685
Ala Gln Met Leu Asp Phe Ile Ser Ser His Thr Phe Val Pro Ile Leu
110                 115                 120                 125

GGC ATT CAT GGG GGC GCA TCT ATG ATC ATG GCT GAC AAG GAT CCG ACG               733
Gly Ile His Gly Gly Ala Ser Met Ile Met Ala Asp Lys Asp Pro Thr
                130                 135                 140

TCT ACC TTC TTC CAG TTT GGA GCG TCC ATC CAG CAG CAA GCC ACG GTC               781
Ser Thr Phe Phe Gln Phe Gly Ala Ser Ile Gln Gln Gln Ala Thr Val
            145                 150                 155

ATG CTG AAG ATC ATG CAG GAT TAT GAC TGG CAT GTC TTC TCC CTG GTG               829
Met Leu Lys Ile Met Gln Asp Tyr Asp Trp His Val Phe Ser Leu Val
        160                 165                 170

ACC ACT ATC TTC CCT GGC TAC AGG GAA TTC ATC AGC TTC GTC AAG ACC               877
Thr Thr Ile Phe Pro Gly Tyr Arg Glu Phe Ile Ser Phe Val Lys Thr
    175                 180                 185

ACA GTG GAC AAC AGC TTT GTG GGC TGG GAC ATG CAG AAT GTG ATC ACA               925
Thr Val Asp Asn Ser Phe Val Gly Trp Asp Met Gln Asn Val Ile Thr
190                 195                 200                 205

CTG GAC ACT TCC TTT GAG GAT GCA AAG ACA CAA GTC CAG CTG AAG AAG               973
Leu Asp Thr Ser Phe Glu Asp Ala Lys Thr Gln Val Gln Leu Lys Lys
                210                 215                 220

ATC CAC TCT TCT GTC ATC TTG CTC TAC TGT TCC AAA GAC GAG GCT GTT              1021
Ile His Ser Ser Val Ile Leu Leu Tyr Cys Ser Lys Asp Glu Ala Val
            225                 230                 235

CTC ATT CTG AGT GAG GCC CGC TCC CTT GGC CTC ACC GGG TAT GAT TTC              1069
Leu Ile Leu Ser Glu Ala Arg Ser Leu Gly Leu Thr Gly Tyr Asp Phe
        240                 245                 250

TTC TGG ATT GTC CCC AGC TTG GTC TCT GGG AAC ACG GAG CTC ATC CCA              1117
Phe Trp Ile Val Pro Ser Leu Val Ser Gly Asn Thr Glu Leu Ile Pro
    255                 260                 265
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AAA GAG TTT CCA TCG GGA CTC ATT TCT GTC TCC TAC GAT GAC TGG GAC      1165
Lys Glu Phe Pro Ser Gly Leu Ile Ser Val Ser Tyr Asp Asp Trp Asp
270                 275                 280                 285

TAC AGC CTG GAG GCG AGA GTG AGG GAC GGC ATT GGC ATC CTA ACC ACC      1213
Tyr Ser Leu Glu Ala Arg Val Arg Asp Gly Ile Gly Ile Leu Thr Thr
                290                 295                 300

GCT GCA TCT TCT ATG CTG GAG AAG TTC TCC TAC ATC CCC GAG GCC AAG      1261
Ala Ala Ser Ser Met Leu Glu Lys Phe Ser Tyr Ile Pro Glu Ala Lys
            305                 310                 315

GCC AGC TGC TAC GGG CAG ATG GAG AGG CCA GAG GTC CCG ATG CAC ACC      1309
Ala Ser Cys Tyr Gly Gln Met Glu Arg Pro Glu Val Pro Met His Thr
        320                 325                 330

TTG CAC CCA TTT ATG GTC AAT GTT ACA TGG GAT GGC AAA GAC TTA TCC      1357
Leu His Pro Phe Met Val Asn Val Thr Trp Asp Gly Lys Asp Leu Ser
    335                 340                 345

TTC ACT GAG GAA GGC TAC CAG GTG CAC CCC AGG CTG GTG GTG ATT GTG      1405
Phe Thr Glu Glu Gly Tyr Gln Val His Pro Arg Leu Val Val Ile Val
350                 355                 360                 365

CTG AAC AAA GAC CGG GAA TGG GAA AAG GTG GGC AAG TGG GAG AAC CAT      1453
Leu Asn Lys Asp Arg Glu Trp Glu Lys Val Gly Lys Trp Glu Asn His
                370                 375                 380

ACG CTG AGC CTG AGG CAC GCC GTG TGG CCC AGG TAC AAG TCC TTC TCC      1501
Thr Leu Ser Leu Arg His Ala Val Trp Pro Arg Tyr Lys Ser Phe Ser
            385                 390                 395

GAC TGT GAG CCG GAT GAC AAC CAT CTC AGC ATC GTC ACC CTG GAG GAG      1549
Asp Cys Glu Pro Asp Asp Asn His Leu Ser Ile Val Thr Leu Glu Glu
        400                 405                 410

GCC CCA TTC GTC ATC GTG GAA GAC ATA GAC CCC CTG ACC GAG ACG TGT      1597
Ala Pro Phe Val Ile Val Glu Asp Ile Asp Pro Leu Thr Glu Thr Cys
    415                 420                 425

GTG AGG AAC ACC GTG CCA TGT CGG AAG TTC GTC AAA ATC AAC AAT TCA      1645
Val Arg Asn Thr Val Pro Cys Arg Lys Phe Val Lys Ile Asn Asn Ser
430                 435                 440                 445

ACC AAT GAG GGG ATG AAT GTG AAG AAA TGC TGC AAG GGG TTC TGC ATT      1693
Thr Asn Glu Gly Met Asn Val Lys Lys Cys Cys Lys Gly Phe Cys Ile
                450                 455                 460

GAT ATT CTG AAG AAG CTT TCC AGA ACT GTG AAG TTT ACT TAC GAC CTC      1741
Asp Ile Leu Lys Lys Leu Ser Arg Thr Val Lys Phe Thr Tyr Asp Leu
            465                 470                 475

TAT CTG GTG ACC AAT GGG AAG CAT GGC AAG AAA GTT AAC AAT GTG TGG      1789
Tyr Leu Val Thr Asn Gly Lys His Gly Lys Lys Val Asn Asn Val Trp
        480                 485                 490

AAT GGA ATG ATC GGT GAA GTG GTC TAT CAA CGG GCA GTC ATG GCA GTT      1837
Asn Gly Met Ile Gly Glu Val Val Tyr Gln Arg Ala Val Met Ala Val
    495                 500                 505

GGC TCG CTC ACC ATC AAT GAG GAA CGT TCT GAA GTG GTG GAC TTC TCT      1885
Gly Ser Leu Thr Ile Asn Glu Glu Arg Ser Glu Val Val Asp Phe Ser
510                 515                 520                 525

GTG CCC TTT GTG GAA ACG GGA ATC AGT GTC ATG GTT TCA AGA AGT AAT      1933
Val Pro Phe Val Glu Thr Gly Ile Ser Val Met Val Ser Arg Ser Asn
                530                 535                 540
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GGC ACC GTC TCA CCT TCT GCT TTT CTA GAA CCA TTC AGC GCC TCT GTC          1981
Gly Thr Val Ser Pro Ser Ala Phe Leu Glu Pro Phe Ser Ala Ser Val
            545                 550                 555

TGG GTG ATG ATG TTT GTG ATG CTG CTC ATT GTT TCT GCC ATA GCT GTT          2029
Trp Val Met Met Phe Val Met Leu Leu Ile Val Ser Ala Ile Ala Val
        560                 565                 570

TGG GTC TTG GAT TAC TCC AGC CCT GTT GGA TAC AAC AGA AAC TTA GCC          2077
Trp Val Leu Asp Tyr Ser Ser Pro Val Gly Tyr Asn Arg Asn Leu Ala
    575                 580                 585

AAA GGG AAA GCA CCC CAT GGG CCT TCT TTT ACA ATT GGA AAA GCT ATA          2125
Lys Gly Lys Ala Pro His Gly Pro Ser Phe Thr Ile Gly Lys Ala Ile
590                 595                 600                 605

TGG CTT CTT TGG GGC CTG GTG TTC AAT AAC TCC GTG CCT GTC CAG AAT          2173
Trp Leu Leu Trp Gly Leu Val Phe Asn Asn Ser Val Pro Val Gln Asn
                610                 615                 620

CCT AAA GGG ACC ACC AGC AAG ATC ATG GTA TCT GTA TGG GCC TTC TTC          2221
Pro Lys Gly Thr Thr Ser Lys Ile Met Val Ser Val Trp Ala Phe Phe
            625                 630                 635

GCT GTC ATA TTC CTG GCT AGC TAC ACA GCC AAT CTG GCT GCC TTC ATG          2269
Ala Val Ile Phe Leu Ala Ser Tyr Thr Ala Asn Leu Ala Ala Phe Met
        640                 645                 650

ATC CAA GAG GAA TTT GTG GAC CAA GTG ACC GGC CTC AGT GAC AAA AAG          2317
Ile Gln Glu Glu Phe Val Asp Gln Val Thr Gly Leu Ser Asp Lys Lys
    655                 660                 665

TTT CAG AGA CCT CAT GAC TAT TCC CCA CCT TTT CGA TTT GGG ACA GTG          2365
Phe Gln Arg Pro His Asp Tyr Ser Pro Pro Phe Arg Phe Gly Thr Val
670                 675                 680                 685

CCT AAT GGA AGC ACG GAG AGA AAC ATT CGG AAT AAC TAT CCC TAC ATG          2413
Pro Asn Gly Ser Thr Glu Arg Asn Ile Arg Asn Asn Tyr Pro Tyr Met
                690                 695                 700

CAT CAG TAC ATG ACC AAA TTT AAT CAG AAA GGA GTA GAG GAC GCC TTG          2461
His Gln Tyr Met Thr Lys Phe Asn Gln Lys Gly Val Glu Asp Ala Leu
            705                 710                 715

GTC AGC CTG AAA ACG GGG AAG CTG GAC GCT TTC ATC TAC GAT GCC GCA          2509
Val Ser Leu Lys Thr Gly Lys Leu Asp Ala Phe Ile Tyr Asp Ala Ala
        720                 725                 730

GTC TTG AAT TAC AAG GCT GGG AGG GAT GAA GGC TGC AAG CTG GTG ACC          2557
Val Leu Asn Tyr Lys Ala Gly Arg Asp Glu Gly Cys Lys Leu Val Thr
    735                 740                 745

ATC GGG AGT GGG TAC ATC TTT GCC ACC ACC GGT TAT GGA ATT GCC CTT          2605
Ile Gly Ser Gly Tyr Ile Phe Ala Thr Thr Gly Tyr Gly Ile Ala Leu
750                 755                 760                 765

CAG AAA GGC TCT CCT TGG AAG AGG CAG ATC GAC CTG GCC TTG CTT CAG          2653
Gln Lys Gly Ser Pro Trp Lys Arg Gln Ile Asp Leu Ala Leu Leu Gln
                770                 775                 780

TTT GTG GGT GAT GGT GAG ATG GAG GAG CTG GAG ACC CTG TGG CTC ACT          2701
Phe Val Gly Asp Gly Glu Met Glu Glu Leu Glu Thr Leu Trp Leu Thr
            785                 790                 795

GGG ATC TGC CAC AAC GAG AAG AAC GAG GTG ATG AGC AGC CAG CTG GAC          2749
Gly Ile Cys His Asn Glu Lys Asn Glu Val Met Ser Ser Gln Leu Asp
        800                 805                 810
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ATT GAC AAC ATG GCG GGC GTA TTC TAC ATG CTG GCT GCC GCC ATG GCC      2797
Ile Asp Asn Met Ala Gly Val Phe Tyr Met Leu Ala Ala Ala Met Ala
    815                 820                 825

CTT AGC CTC ATC ACC TTC ATC TGG GAG CAC CTC TTC TAC TGG AAG CTG      2845
Leu Ser Leu Ile Thr Phe Ile Trp Glu His Leu Phe Tyr Trp Lys Leu
830                 835                 840                 845

CGC TTC TGT TTC ACG GGC GTG TGC TCC GAC CGG CCT GGG TTG CTC TTC      2893
Arg Phe Cys Phe Thr Gly Val Cys Ser Asp Arg Pro Gly Leu Leu Phe
                850                 855                 860

TCC ATC AGC AGG GGC ATC TAC AGC TGC ATT CAT GGA GTG CAC ATT GAA      2941
Ser Ile Ser Arg Gly Ile Tyr Ser Cys Ile His Gly Val His Ile Glu
            865                 870                 875

GAA AAG AAG AAG TCT CCA GAC TTC AAT CTG ACG GGA TCC CAG AGC AAC      2989
Glu Lys Lys Lys Ser Pro Asp Phe Asn Leu Thr Gly Ser Gln Ser Asn
        880                 885                 890

ATG TTA AAA CTC CTC CGG TCA GCC AAA AAC ATT TCC AGC ATG TCC AAC      3037
Met Leu Lys Leu Leu Arg Ser Ala Lys Asn Ile Ser Ser Met Ser Asn
    895                 900                 905

ATG AAC TCC TCA AGA ATG GAC TCA CCC AAA AGA GCT GCT GAC TTC ATC      3085
Met Asn Ser Ser Arg Met Asp Ser Pro Lys Arg Ala Ala Asp Phe Ile
910                 915                 920                 925

CAA AGA GGT TCC CTC ATC ATG GAC ATG GTT TCA GAT AAG GGG AAT TTG      3133
Gln Arg Gly Ser Leu Ile Met Asp Met Val Ser Asp Lys Gly Asn Leu
                930                 935                 940

ATG TAC TCA GAC AAC AGG TCC TTT CAG GGG AAA GAG AGC ATT TTT GGA      3181
Met Tyr Ser Asp Asn Arg Ser Phe Gln Gly Lys Glu Ser Ile Phe Gly
            945                 950                 955

GAC AAC ATG AAC GAA CTC CAA ACA TTT GTG GCC AAC CGG CAG AAG GAT      3229
Asp Asn Met Asn Glu Leu Gln Thr Phe Val Ala Asn Arg Gln Lys Asp
        960                 965                 970

AAC CTC AAT AAC TAT GTA TTC CAG GGA CAA CAT CCT CTT ACT CTC AAT      3277
Asn Leu Asn Asn Tyr Val Phe Gln Gly Gln His Pro Leu Thr Leu Asn
    975                 980                 985

GAG TCC AAC CCT AAC ACG GTG GAG GTG GCC GTG AGC ACA GAA TCC AAA      3325
Glu Ser Asn Pro Asn Thr Val Glu Val Ala Val Ser Thr Glu Ser Lys
990                 995                 1000                1005

GCG AAC TCT AGA CCC CGG CAG CTG TGG AAG AAA TCC GTG GAT TCC ATA      3373
Ala Asn Ser Arg Pro Arg Gln Leu Trp Lys Lys Ser Val Asp Ser Ile
                1010                1015                1020

CGC CAG GAT TCA CTA TCC CAG AAT CCA GTC TCC CAG AGG GAT GAG GCA      3421
Arg Gln Asp Ser Leu Ser Gln Asn Pro Val Ser Gln Arg Asp Glu Ala
            1025                1030                1035

ACA GCA GAG AAT AGG ACC CAC TCC CTA AAG AGC CCT AGG TAT CTT CCA      3469
Thr Ala Glu Asn Arg Thr His Ser Leu Lys Ser Pro Arg Tyr Leu Pro
        1040                1045                1050

GAA GAG ATG GCC CAC TCT GAC ATT TCA GAA ACG TCA AAT CGG GCC ACG      3517
Glu Glu Met Ala His Ser Asp Ile Ser Glu Thr Ser Asn Arg Ala Thr
    1055                1060                1065

TGC CAC AGG GAA CCT GAC AAC AGT AAG AAC CAC AAA ACC AAG GAC AAC      3565
Cys His Arg Glu Pro Asp Asn Ser Lys Asn His Lys Thr Lys Asp Asn
1070                1075                1080                1085
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TTT AAA AGG TCA GTG GCC TCC AAA TAC CCC AAG GAC TGT AGT GAG GTC      3613
Phe Lys Arg Ser Val Ala Ser Lys Tyr Pro Lys Asp Cys Ser Glu Val
                1090                1095                1100

GAG CGC ACC TAC CTG AAA ACC AAA TCA AGC TCC CCT AGA GAC AAG ATC      3661
Glu Arg Thr Tyr Leu Lys Thr Lys Ser Ser Ser Pro Arg Asp Lys Ile
            1105                1110                1115

TAC ACT ATA GAT GGT GAG AAG GAG CCT GGT TTC CAC TTA GAT CCA CCC      3709
Tyr Thr Ile Asp Gly Glu Lys Glu Pro Gly Phe His Leu Asp Pro Pro
        1120                1125                1130

CAG TTT GTT GAA AAT GTG ACC CTG CCC GAG AAC GTG GAC TTC CCG GAC      3757
Gln Phe Val Glu Asn Val Thr Leu Pro Glu Asn Val Asp Phe Pro Asp
    1135                1140                1145

CCC TAC CAG GAT CCC AGT GAA AAC TTC CGC AAG GGG GAC TCC ACG CTG      3805
Pro Tyr Gln Asp Pro Ser Glu Asn Phe Arg Lys Gly Asp Ser Thr Leu
1150                1155                1160                1165

CCA ATG AAC CGG AAC CCC TTG CAT AAT GAA GAG GGG CTT TCC AAC AAC      3853
Pro Met Asn Arg Asn Pro Leu His Asn Glu Glu Gly Leu Ser Asn Asn
                1170                1175                1180

GAC CAG TAT AAA CTC TAC TCC AAG CAC TTC ACC TTG AAA GAC AAG GGT      3901
Asp Gln Tyr Lys Leu Tyr Ser Lys His Phe Thr Leu Lys Asp Lys Gly
            1185                1190                1195

TCC CCG CAC AGT GAG ACC AGC GAG CGA TAC CGG CAG AAC TCC ACG CAC      3949
Ser Pro His Ser Glu Thr Ser Glu Arg Tyr Arg Gln Asn Ser Thr His
        1200                1205                1210

TGC AGA AGC TGC CTT TCC AAC ATG CCC ACC TAT TCA GGC CAC TTC ACC      3997
Cys Arg Ser Cys Leu Ser Asn Met Pro Thr Tyr Ser Gly His Phe Thr
    1215                1220                1225

ATG AGG TCC CCC TTC AAG TGC GAT GCC TGC CTG CGG ATG GGG AAC CTC      4045
Met Arg Ser Pro Phe Lys Cys Asp Ala Cys Leu Arg Met Gly Asn Leu
1230                1235                1240                1245

TAT GAC ATC GAT GAA GAC CAG ATG CTT CAG GAG ACA GGT AAC CCA GCC      4093
Tyr Asp Ile Asp Glu Asp Gln Met Leu Gln Glu Thr Gly Asn Pro Ala
                1250                1255                1260

ACC GGG GAG CAG GTC TAC CAG CAG GAC TGG GCA CAG AAC AAT GCC CTT      4141
Thr Gly Glu Gln Val Tyr Gln Gln Asp Trp Ala Gln Asn Asn Ala Leu
            1265                1270                1275

CAA TTA CAA AAG AAC AAG CTA AGG ATT AGC CGT CAG CAT TCC TAC GAT      4189
Gln Leu Gln Lys Asn Lys Leu Arg Ile Ser Arg Gln His Ser Tyr Asp
        1280                1285                1290

AAC ATT GTC GAC AAA CCT AGG GAG CTA GAC CTT AGC AGG CCC TCC CGG      4237
Asn Ile Val Asp Lys Pro Arg Glu Leu Asp Leu Ser Arg Pro Ser Arg
    1295                1300                1305

AGC ATA AGC CTC AAG GAC AGG GAA CGG CTT CTG GAG GGA AAT TTT TAC      4285
Ser Ile Ser Leu Lys Asp Arg Glu Arg Leu Leu Glu Gly Asn Phe Tyr
1310                1315                1320                1325

GGC AGC CTG TTT AGT GTC CCC TCA AGC AAA CTC TCG GGG AAA AAA AGC      4333
Gly Ser Leu Phe Ser Val Pro Ser Ser Lys Leu Ser Gly Lys Lys Ser
                1330                1335                1340

TCC CTT TTC CCC CAA GGT CTG GAG GAC AGC AAG AGG AGC AAG TCT CTC      4381
Ser Leu Phe Pro Gln Gly Leu Glu Asp Ser Lys Arg Ser Lys Ser Leu
            1345                1350                1355
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TTG CCA GAC CAC ACC TCC GAT AAC CCT TTC CTC CAC TCC CAC AGG GAT      4429
Leu Pro Asp His Thr Ser Asp Asn Pro Phe Leu His Ser His Arg Asp
        1360                1365                1370

GAC CAA CGC TTG GTT ATT GGG AGA TGC CCC TCG GAC CCT TAC AAA CAC      4477
Asp Gln Arg Leu Val Ile Gly Arg Cys Pro Ser Asp Pro Tyr Lys His
    1375                1380                1385

TCG TTG CCA TCC CAG GCG GTG AAT GAC AGC TAT CTT CGG TCG TCC TTG      4525
Ser Leu Pro Ser Gln Ala Val Asn Asp Ser Tyr Leu Arg Ser Ser Leu
1390                1395                1400                1405

AGG TCA ACG GCA TCG TAC TGT TCC AGG GAC AGT CGG GGC CAC AAT GAT      4573
Arg Ser Thr Ala Ser Tyr Cys Ser Arg Asp Ser Arg Gly His Asn Asp
                1410                1415                1420

GTG TAT ATT TCG GAG CAT GTT ATG CCT TAT GCT GCA AAT AAG AAT AAT      4621
Val Tyr Ile Ser Glu His Val Met Pro Tyr Ala Ala Asn Lys Asn Asn
            1425                1430                1435

ATG TAC TCT ACC CCC AGG GTT TTA AAT TCC TGC AGC AAT AGA CGC GTG      4669
Met Tyr Ser Thr Pro Arg Val Leu Asn Ser Cys Ser Asn Arg Arg Val
        1440                1445                1450

TAC AAG GAA ATG CCT AGT ATC GAA TCT GAT GTT TAAAAATCTT CCATTAATGT    4722
Tyr Lys Glu Met Pro Ser Ile Glu Ser Asp Val
    1455                1460                146

TTTATCTATA GGGAAATACA CGTAATGGCC AATGTTCTGG AGGGTAAATG TTGGATGTCC    4782

AATAGTGCCC TGCTAAGAGG AAGGAG                                         4808
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(2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1464 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

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Met Gly Arg Val Gly Tyr Trp Thr Leu Leu Val Leu Pro Ala Leu Leu
 1               5                  10                  15

Val Trp Arg Gly Pro Ala Pro Ser Ala Ala Ala Glu Lys Gly Pro Pro
            20                  25                  30

Ala Leu Asn Ile Ala Val Met Leu Gly His Ser His Asp Val Thr Glu
        35                  40                  45

Arg Glu Leu Arg Thr Leu Trp Gly Pro Glu Gln Ala Ala Gly Leu Pro
    50                  55                  60

Leu Asp Val Asn Val Val Ala Leu Leu Met Asn Arg Thr Asp Pro Lys
65                  70                  75                  80

Ser Leu Ile Thr His Val Cys Asp Leu Met Ser Gly Ala Arg Ile His
                85                  90                  95

Gly Leu Val Phe Gly Asp Asp Thr Asp Gln Glu Ala Val Ala Gln Met
            100                 105                 110

Leu Asp Phe Ile Ser Ser His Thr Phe Val Pro Ile Leu Gly Ile His
        115                 120                 125
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Gly Gly Ala Ser Met Ile Met Ala Asp Lys Asp Pro Thr Ser Thr Phe
130 135 140

Phe Gln Phe Gly Ala Ser Ile Gln Gln Gln Ala Thr Val Met Leu Lys
145 150 155 160

Ile Met Gln Asp Tyr Asp Trp His Val Phe Ser Leu Val Thr Thr Ile
165 170 175

Phe Pro Gly Tyr Arg Glu Phe Ile Ser Phe Val Lys Thr Thr Val Asp
180 185 190

Asn Ser Phe Val Gly Trp Asp Met Gln Asn Val Ile Thr Leu Asp Thr
195 200 205

Ser Phe Glu Asp Ala Lys Thr Gln Val Gln Leu Lys Lys Ile His Ser
210 215 220

Ser Val Ile Leu Leu Tyr Cys Ser Lys Asp Glu Ala Val Leu Ile Leu
225 230 235 240

Ser Glu Ala Arg Ser Leu Gly Leu Thr Gly Tyr Asp Phe Phe Trp Ile
245 250 255

Val Pro Ser Leu Val Ser Gly Asn Thr Glu Leu Ile Pro Lys Glu Phe
260 265 270

Pro Ser Gly Leu Ile Ser Val Ser Tyr Asp Asp Trp Asp Tyr Ser Leu
275 280 285

Glu Ala Arg Val Arg Asp Gly Ile Gly Ile Leu Thr Thr Ala Ala Ser
290 295 300

Ser Met Leu Glu Lys Phe Ser Tyr Ile Pro Glu Ala Lys Ala Ser Cys
305 310 315 320

Tyr Gly Gln Met Glu Arg Pro Glu Val Pro Met His Thr Leu His Pro
325 330 335

Phe Met Val Asn Val Thr Trp Asp Gly Lys Asp Leu Ser Phe Thr Glu
340 345 350

Glu Gly Tyr Gln Val His Pro Arg Leu Val Val Ile Val Leu Asn Lys
355 360 365

Asp Arg Glu Trp Glu Lys Val Gly Lys Trp Glu Asn His Thr Leu Ser
370 375 380

Leu Arg His Ala Val Trp Pro Arg Tyr Lys Ser Phe Ser Asp Cys Glu
385 390 395 400

Pro Asp Asp Asn His Leu Ser Ile Val Thr Leu Glu Glu Ala Pro Phe
405 410 415

Val Ile Val Glu Asp Ile Asp Pro Leu Thr Glu Thr Cys Val Arg Asn
420 425 430

Thr Val Pro Cys Arg Lys Phe Val Lys Ile Asn Asn Ser Thr Asn Glu
435 440 445

Gly Met Asn Val Lys Lys Cys Cys Lys Gly Phe Cys Ile Asp Ile Leu
450 455 460

Lys Lys Leu Ser Arg Thr Val Lys Phe Thr Tyr Asp Leu Tyr Leu Val
465 470 475 480

Thr Asn Gly Lys His Gly Lys Lys Val Asn Asn Val Trp Asn Gly Met
485 490 495

Ile Gly Glu Val Val Tyr Gln Arg Ala Val Met Ala Val Gly Ser Leu
500 505 510

Thr Ile Asn Glu Glu Arg Ser Glu Val Val Asp Phe Ser Val Pro Phe
515 520 525

Val Glu Thr Gly Ile Ser Val Met Val Ser Arg Ser Asn Gly Thr Val
530 535 540

Ser Pro Ser Ala Phe Leu Glu Pro Phe Ser Ala Ser Val Trp Val Met
545 550 555 560

Met Phe Val Met Leu Leu Ile Val Ser Ala Ile Ala Val Trp Val Leu
565 570 575

Asp Tyr Ser Ser Pro Val Gly Tyr Asn Arg Asn Leu Ala Lys Gly Lys
580 585 590

Ala Pro His Gly Pro Ser Phe Thr Ile Gly Lys Ala Ile Trp Leu Leu
595 600 605

Trp Gly Leu Val Phe Asn Asn Ser Val Pro Val Gln Asn Pro Lys Gly
610 615 620

Thr Thr Ser Lys Ile Met Val Ser Val Trp Ala Phe Phe Ala Val Ile
625 630 635 640

Phe Leu Ala Ser Tyr Thr Ala Asn Leu Ala Ala Phe Met Ile Gln Glu
645 650 655

Glu Phe Val Asp Gln Val Thr Gly Leu Ser Asp Lys Lys Phe Gln Arg
660 665 670

Pro His Asp Tyr Ser Pro Pro Phe Arg Phe Gly Thr Val Pro Asn Gly
675 680 685

Ser Thr Glu Arg Asn Ile Arg Asn Asn Tyr Pro Tyr Met His Gln Tyr
690 695 700

Met Thr Lys Phe Asn Gln Lys Gly Val Glu Asp Ala Leu Val Ser Leu
705 710 715 720

Lys Thr Gly Lys Leu Asp Ala Phe Ile Tyr Asp Ala Ala Val Leu Asn
725 730 735

Tyr Lys Ala Gly Arg Asp Glu Gly Cys Lys Leu Val Thr Ile Gly Ser
740 745 750

Gly Tyr Ile Phe Ala Thr Thr Gly Tyr Gly Ile Ala Leu Gln Lys Gly
755 760 765

Ser Pro Trp Lys Arg Gln Ile Asp Leu Ala Leu Leu Gln Phe Val Gly
770 775 780

Asp Gly Glu Met Glu Glu Leu Glu Thr Leu Trp Leu Thr Gly Ile Cys
785 790 795 800

His Asn Glu Lys Asn Glu Val Met Ser Ser Gln Leu Asp Ile Asp Asn
805 810 815

Met Ala Gly Val Phe Tyr Met Leu Ala Ala Ala Met Ala Leu Ser Leu
820 825 830

Ile Thr Phe Ile Trp Glu His Leu Phe Tyr Trp Lys Leu Arg Phe Cys
835 840 845

Phe Thr Gly Val Cys Ser Asp Arg Pro Gly Leu Leu Phe Ser Ile Ser
850 855 860

Arg Gly Ile Tyr Ser Cys Ile His Gly Val His Ile Glu Glu Lys Lys
865 870 875 880

Lys Ser Pro Asp Phe Asn Leu Thr Gly Ser Gln Ser Asn Met Leu Lys
885 890 895

Leu Leu Arg Ser Ala Lys Asn Ile Ser Ser Met Ser Asn Met Asn Ser
900 905 910

Ser Arg Met Asp Ser Pro Lys Arg Ala Ala Asp Phe Ile Gln Arg Gly
915 920 925

Ser Leu Ile Met Asp Met Val Ser Asp Lys Gly Asn Leu Met Tyr Ser
930 935 940

Asp Asn Arg Ser Phe Gln Gly Lys Glu Ser Ile Phe Gly Asp Asn Met
945 950 955 960

Asn Glu Leu Gln Thr Phe Val Ala Asn Arg Gln Lys Asp Asn Leu Asn
965 970 975

Asn Tyr Val Phe Gln Gly Gln His Pro Leu Thr Leu Asn Glu Ser Asn
980 985 990

Pro Asn Thr Val Glu Val Ala Val Ser Thr Glu Ser Lys Ala Asn Ser
995 1000 1005

Arg Pro Arg Gln Leu Trp Lys Lys Ser Val Asp Ser Ile Arg Gln Asp
1010 1015 1020

Ser Leu Ser Gln Asn Pro Val Ser Gln Arg Asp Glu Ala Thr Ala Glu
1025 1030 1035 1040

Asn Arg Thr His Ser Leu Lys Ser Pro Arg Tyr Leu Pro Glu Glu Met
1045 1050 1055

Ala His Ser Asp Ile Ser Glu Thr Ser Asn Arg Ala Thr Cys His Arg
1060 1065 1070

Glu Pro Asp Asn Ser Lys Asn His Lys Thr Lys Asp Asn Phe Lys Arg
1075 1080 1085

Ser Val Ala Ser Lys Tyr Pro Lys Asp Cys Ser Glu Val Glu Arg Thr
1090 1095 1100

Tyr Leu Lys Thr Lys Ser Ser Ser Pro Arg Asp Lys Ile Tyr Thr Ile
1105 1110 1115 1120

Asp Gly Glu Lys Glu Pro Gly Phe His Leu Asp Pro Pro Gln Phe Val
1125 1130 1135

Glu Asn Val Thr Leu Pro Glu Asn Val Asp Phe Pro Asp Pro Tyr Gln
1140 1145 1150

Asp Pro Ser Glu Asn Phe Arg Lys Gly Asp Ser Thr Leu Pro Met Asn
1155 1160 1165

Arg Asn Pro Leu His Asn Glu Glu Gly Leu Ser Asn Asn Asp Gln Tyr
1170 1175 1180

Lys Leu Tyr Ser Lys His Phe Thr Leu Lys Asp Lys Gly Ser Pro His
1185 1190 1195 1200

Ser Glu Thr Ser Glu Arg Tyr Arg Gln Asn Ser Thr His Cys Arg Ser
1205 1210 1215

Cys Leu Ser Asn Met Pro Thr Tyr Ser Gly His Phe Thr Met Arg Ser
1220 1225 1230

Pro Phe Lys Cys Asp Ala Cys Leu Arg Met Gly Asn Leu Tyr Asp Ile
1235 1240 1245

Asp Glu Asp Gln Met Leu Gln Glu Thr Gly Asn Pro Ala Thr Gly Glu
1250 1255 1260

Gln Val Tyr Gln Gln Asp Trp Ala Gln Asn Asn Ala Leu Gln Leu Gln
1265 1270 1275 1280

Lys Asn Lys Leu Arg Ile Ser Arg Gln His Ser Tyr Asp Asn Ile Val
1285 1290 1295

Asp Lys Pro Arg Glu Leu Asp Leu Ser Arg Pro Ser Arg Ser Ile Ser
1300 1305 1310

Leu Lys Asp Arg Glu Arg Leu Leu Glu Gly Asn Phe Tyr Gly Ser Leu
1315 1320 1325

Phe Ser Val Pro Ser Ser Lys Leu Ser Gly Lys Lys Ser Ser Leu Phe
1330 1335 1340

Pro Gln Gly Leu Glu Asp Ser Lys Arg Ser Lys Ser Leu Leu Pro Asp
1345 1350 1355 1360

His Thr Ser Asp Asn Pro Phe Leu His Ser His Arg Asp Asp Gln Arg
1365 1370 1375

Leu Val Ile Gly Arg Cys Pro Ser Asp Pro Tyr Lys His Ser Leu Pro
1380 1385 1390

Ser Gln Ala Val Asn Asp Ser Tyr Leu Arg Ser Ser Leu Arg Ser Thr
1395 1400 1405

Ala Ser Tyr Cys Ser Arg Asp Ser Arg Gly His Asn Asp Val Tyr Ile
1410 1415 1420

Ser Glu His Val Met Pro Tyr Ala Ala Asn Lys Asn Asn Met Tyr Ser
1425 1430 1435 1440

Thr Pro Arg Val Leu Asn Ser Cys Ser Asn Arg Arg Val Tyr Lys Glu
1445 1450 1455

Met Pro Ser Ile Glu Ser Asp Val
1460

(2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 74 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

CGAGGGAGGC GGCCGGCGCG GACTCTCTTC GCGGGCGCAG CGCCCCTTCC CCCTCGGACC 60

CTCCGGTGGA CATG 74

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 5538 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 210..4664

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

TTGAATTTGC ATCTCTTCAA GACACAAGAT TAAAACAAAA TTTACGCTAA ATTGGATTTT 60

AAATTATCTT CCGTTCATTT ATCCTTCGTC TTTCTTATGT GGATATGCAA GCGAGAAGAA 120

GGGACTGGAC ATTCCCAACA TGCTCACTCC CTTAATCTGT CCGTCTAGAG GTTTGGCTTC 180

TACAAACCAA GGGAGTCGAC GAGTTGAAG ATG AAG CCC AGA GCG GAG TGC TGT 233
Met Lys Pro Arg Ala Glu Cys Cys
1 5

TCT CCC AAG TTC TGG TTG GTG TTG GCC GTC CTG GCC GTG TCA GGC AGC 281
Ser Pro Lys Phe Trp Leu Val Leu Ala Val Leu Ala Val Ser Gly Ser
10 15 20

AGA GCT CGT TCT CAG AAG AGC CCC CCC AGC ATT GGC ATT GCT GTC ATC 329
Arg Ala Arg Ser Gln Lys Ser Pro Pro Ser Ile Gly Ile Ala Val Ile
25 30 35 40

CTC GTG GGC ACT TCC GAC GAG GTG GCC ATC AAG GAT GCC CAC GAG AAA 377
Leu Val Gly Thr Ser Asp Glu Val Ala Ile Lys Asp Ala His Glu Lys
45 50 55

GAT GAT TTC CAC CAT CTC TCC GTG GTA CCC CGG GTG GAA CTG GTA GCC 425
Asp Asp Phe His His Leu Ser Val Val Pro Arg Val Glu Leu Val Ala
60 65 70

ATG AAT GAG ACC GAC CCA AAG AGC ATC ATC ACC CGC ATC TGT GAT CTC 473
Met Asn Glu Thr Asp Pro Lys Ser Ile Ile Thr Arg Ile Cys Asp Leu
75 80 85

ATG TCT GAC CGG AAG ATC CAG GGG GTG GTG TTT GCT GAT GAC ACA GAC 521
Met Ser Asp Arg Lys Ile Gln Gly Val Val Phe Ala Asp Asp Thr Asp
90 95 100

CAG GAA GCC ATC GCC CAG ATC CTC GAT TTC ATT TCA GCA CAG ACT CTC 569
Gln Glu Ala Ile Ala Gln Ile Leu Asp Phe Ile Ser Ala Gln Thr Leu
105 110 115 120

ACC CCG ATC CTG GGC ATC CAC GGG GGC TCC TCT ATG ATA ATG GCA GAT 617
Thr Pro Ile Leu Gly Ile His Gly Gly Ser Ser Met Ile Met Ala Asp
125 130 135

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AAG GAT GAA TCC TCC ATG TTC TTC CAG TTT GGC CCA TCA ATT GAA CAG          665
Lys Asp Glu Ser Ser Met Phe Phe Gln Phe Gly Pro Ser Ile Glu Gln
            140                 145                 150

CAA GCT TCC GTA ATG CTC AAC ATC ATG GAA GAA TAT GAC TGG TAC ATC          713
Gln Ala Ser Val Met Leu Asn Ile Met Glu Glu Tyr Asp Trp Tyr Ile
        155                 160                 165

TTT TCT ATC GTC ACC ACC TAT TTC CCT GGC TAC CAG GAC TTT GTA AAC          761
Phe Ser Ile Val Thr Thr Tyr Phe Pro Gly Tyr Gln Asp Phe Val Asn
    170                 175                 180

AAG ATC CGC AGC ACC ATT GAG AAT AGC TTT GTG GGC TGG GAG CTA GAG          809
Lys Ile Arg Ser Thr Ile Glu Asn Ser Phe Val Gly Trp Glu Leu Glu
185                 190                 195                 200

GAG GTC CTC CTA CTG GAC ATG TCC CTG GAC GAT GGA GAT TCT AAG ATC          857
Glu Val Leu Leu Leu Asp Met Ser Leu Asp Asp Gly Asp Ser Lys Ile
                205                 210                 215

CAG AAT CAG CTC AAG AAA CTT CAA AGC CCC ATC ATT CTT CTT TAC TGT          905
Gln Asn Gln Leu Lys Lys Leu Gln Ser Pro Ile Ile Leu Leu Tyr Cys
            220                 225                 230

ACC AAG GAA GAA GCC ACC TAC ATC TTT GAA GTG GCC AAC TCA GTA GGG          953
Thr Lys Glu Glu Ala Thr Tyr Ile Phe Glu Val Ala Asn Ser Val Gly
        235                 240                 245

CTG ACT GGC TAT GGC TAC ACG TGG ATC GTG CCC AGT CTG GTG GCA GGG         1001
Leu Thr Gly Tyr Gly Tyr Thr Trp Ile Val Pro Ser Leu Val Ala Gly
    250                 255                 260

GAT ACA GAC ACA GTG CCT GCG GAG TTC CCC ACT GGG CTC ATC TCT GTA         1049
Asp Thr Asp Thr Val Pro Ala Glu Phe Pro Thr Gly Leu Ile Ser Val
265                 270                 275                 280

TCA TAT GAT GAA TGG GAC TAT GGC CTC CCC CCC AGA GTG AGA GAT GGA         1097
Ser Tyr Asp Glu Trp Asp Tyr Gly Leu Pro Pro Arg Val Arg Asp Gly
                285                 290                 295

ATT GCC ATA ATC ACC ACT GCT GCT TCT GAC ATG CTG TCT GAG CAC AGC         1145
Ile Ala Ile Ile Thr Thr Ala Ala Ser Asp Met Leu Ser Glu His Ser
            300                 305                 310

TTC ATC CCT GAG CCC AAA AGC AGT TGT TAC AAC ACC CAC GAG AAG AGA         1193
Phe Ile Pro Glu Pro Lys Ser Ser Cys Tyr Asn Thr His Glu Lys Arg
        315                 320                 325

ATC TAC CAG TCC AAT ATG CTA AAT AGG TAT CTG ATC AAT GTC ACT TTT         1241
Ile Tyr Gln Ser Asn Met Leu Asn Arg Tyr Leu Ile Asn Val Thr Phe
    330                 335                 340

GAG GGG AGG AAT TTG TCC TTC AGT GAA GAT GGC TAC CAG ATG CAC CCG         1289
Glu Gly Arg Asn Leu Ser Phe Ser Glu Asp Gly Tyr Gln Met His Pro
345                 350                 355                 360

AAA CTG GTG ATA ATT CTT CTG AAC AAG GAG AGG AAG TGG GAA AGG GTG         1337
Lys Leu Val Ile Ile Leu Leu Asn Lys Glu Arg Lys Trp Glu Arg Val
                365                 370                 375

GGG AAG TGG AAA GAC AAG TCC CTG CAG ATG AAG TAC TAT GTG TGG CCC         1385
Gly Lys Trp Lys Asp Lys Ser Leu Gln Met Lys Tyr Tyr Val Trp Pro
            380                 385                 390

CGA ATG TGT CCA GAG ACT GAA GAG CAG GAG GAT GAC CAT CTG AGC ATT         1433
Arg Met Cys Pro Glu Thr Glu Glu Gln Glu Asp Asp His Leu Ser Ile
        395                 400                 405
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GTG ACC CTG GAG GAG GCA CCA TTT GTC ATT GTG GAA AGT GTG GAC CCT      1481
Val Thr Leu Glu Glu Ala Pro Phe Val Ile Val Glu Ser Val Asp Pro
    410                 415                 420

CTG AGT GGA ACC TGC ATG AGG AAC ACA GTC CCC TGC CAA AAA CGC ATA      1529
Leu Ser Gly Thr Cys Met Arg Asn Thr Val Pro Cys Gln Lys Arg Ile
425                 430                 435                 440

GTC ACT GAG AAT AAA ACA GAC GAG GAG CCG GGT TAC ATC AAA AAA TGC      1577
Val Thr Glu Asn Lys Thr Asp Glu Glu Pro Gly Tyr Ile Lys Lys Cys
                445                 450                 455

TGC AAG GGG TTC TGT ATT GAC ATC CTT AAG AAA ATT TCT AAA TCT GTG      1625
Cys Lys Gly Phe Cys Ile Asp Ile Leu Lys Lys Ile Ser Lys Ser Val
            460                 465                 470

AAG TTC ACC TAT GAC CTT TAC CTG GTT ACC AAT GGC AAG CAT GGG AAG      1673
Lys Phe Thr Tyr Asp Leu Tyr Leu Val Thr Asn Gly Lys His Gly Lys
        475                 480                 485

AAA ATC AAT GGA ACC TGG AAT GGT ATG ATT GGA GAG GTG GTC ATG AAG      1721
Lys Ile Asn Gly Thr Trp Asn Gly Met Ile Gly Glu Val Val Met Lys
    490                 495                 500

AGG GCC TAC ATG GCA GTG GGC TCA CTC ACC ATC AAT GAG GAA CGA TCG      1769
Arg Ala Tyr Met Ala Val Gly Ser Leu Thr Ile Asn Glu Glu Arg Ser
505                 510                 515                 520

GAG GTG GTC GAC TTC TCT GTG CCC TTC ATA GAG ACA GGC ATC AGT GTC      1817
Glu Val Val Asp Phe Ser Val Pro Phe Ile Glu Thr Gly Ile Ser Val
                525                 530                 535

ATG GTG TCA CGC AGC AAT GGG ACT GTC TCA CCT TCT GCC TTC TTA GAG      1865
Met Val Ser Arg Ser Asn Gly Thr Val Ser Pro Ser Ala Phe Leu Glu
            540                 545                 550

CCA TTC AGC GCT GAC GTA TGG GTG ATG ATG TTT GTG ATG CTG CTC ATC      1913
Pro Phe Ser Ala Asp Val Trp Val Met Met Phe Val Met Leu Leu Ile
        555                 560                 565

GTC TCA GCC GTG GCT GTC TTT GTC TTT GAG TAC TTC AGC CCT GTG GGT      1961
Val Ser Ala Val Ala Val Phe Val Phe Glu Tyr Phe Ser Pro Val Gly
    570                 575                 580

TAT AAC AGG TGC CTC GCT GAT GGC AGA GAG CCT GGT GGA CCC TCT TTC      2009
Tyr Asn Arg Cys Leu Ala Asp Gly Arg Glu Pro Gly Gly Pro Ser Phe
585                 590                 595                 600

ACC ATC GGC AAA GCT ATT TGG TTG CTC TGG GGT CTG GTG TTT AAC AAC      2057
Thr Ile Gly Lys Ala Ile Trp Leu Leu Trp Gly Leu Val Phe Asn Asn
                605                 610                 615

TCC GTA CCT GTG CAG AAC CCA AAG GGG ACC ACC TCC AAG ATC ATG GTG      2105
Ser Val Pro Val Gln Asn Pro Lys Gly Thr Thr Ser Lys Ile Met Val
            620                 625                 630

TCA GTG TGG GCC TTC TTT GCT GTC ATC TTC CTG GCC AGC TAC ACT GCC      2153
Ser Val Trp Ala Phe Phe Ala Val Ile Phe Leu Ala Ser Tyr Thr Ala
        635                 640                 645

AAC TTA GCT GCC TTC ATG ATC CAA GAG GAA TAT GTG GAC CAG GTT TCT      2201
Asn Leu Ala Ala Phe Met Ile Gln Glu Glu Tyr Val Asp Gln Val Ser
    650                 655                 660

GGC CTG AGC GAC AAA AAG TTC CAG AGA CCT AAT GAC TTC TCA CCC CCT      2249
Gly Leu Ser Asp Lys Lys Phe Gln Arg Pro Asn Asp Phe Ser Pro Pro
665                 670                 675                 680
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TTC CGC TTT GGG ACC GTG CCC AAC GGC AGC ACA GAG AGA AAT ATT CGC          2297
Phe Arg Phe Gly Thr Val Pro Asn Gly Ser Thr Glu Arg Asn Ile Arg
                685                 690                 695

AAT AAC TAT GCA GAA ATG CAT GCC TAC ATG GGA AAG TTC AAC CAG AGG          2345
Asn Asn Tyr Ala Glu Met His Ala Tyr Met Gly Lys Phe Asn Gln Arg
            700                 705                 710

GGT GTA GAT GAT GCA TTG CTC TCC CTG AAA ACA GGG AAA CTG GAT GCC          2393
Gly Val Asp Asp Ala Leu Leu Ser Leu Lys Thr Gly Lys Leu Asp Ala
        715                 720                 725

TTC ATC TAT GAT GCA GCA GTG CTG AAC TAT ATG GCA GGC AGA GAT GAA          2441
Phe Ile Tyr Asp Ala Ala Val Leu Asn Tyr Met Ala Gly Arg Asp Glu
    730                 735                 740

GGC TGC AAG CTG GTG ACC ATT GGC AGT GGG AAG GTC TTT GCT TCC ACT          2489
Gly Cys Lys Leu Val Thr Ile Gly Ser Gly Lys Val Phe Ala Ser Thr
745                 750                 755                 760

GGC TAT GGC ATT GCC ATC CAA AAA GAT TCT GGG TGG AAG CGC CAG GTG          2537
Gly Tyr Gly Ile Ala Ile Gln Lys Asp Ser Gly Trp Lys Arg Gln Val
                765                 770                 775

GAC CTT GCT ATC CTG CAG CTC TTT GGA GAT GGG GAG ATG GAA GAA CTG          2585
Asp Leu Ala Ile Leu Gln Leu Phe Gly Asp Gly Glu Met Glu Glu Leu
            780                 785                 790

GAA GCT CTC TGG CTC ACT GGC ATT TGT CAC AAT GAG AAG AAT GAG GTC          2633
Glu Ala Leu Trp Leu Thr Gly Ile Cys His Asn Glu Lys Asn Glu Val
        795                 800                 805

ATG AGC AGC CAG CTG GAC ATT GAC AAC ATG GCA GGG GTC TTC TAC ATG          2681
Met Ser Ser Gln Leu Asp Ile Asp Asn Met Ala Gly Val Phe Tyr Met
    810                 815                 820

TTG GGG GCG GCC ATG GCT CTC AGC CTC ATC ACC TTC ATC TGC GAA CAC          2729
Leu Gly Ala Ala Met Ala Leu Ser Leu Ile Thr Phe Ile Cys Glu His
825                 830                 835                 840

CTT TTC TAT TGG CAG TTC CGA CAT TGC TTT ATG GGT GTC TGT TCT GGC          2777
Leu Phe Tyr Trp Gln Phe Arg His Cys Phe Met Gly Val Cys Ser Gly
                845                 850                 855

AAG CCT GGC ATG GTC TTC TCC ATC AGC AGA GGT ATC TAC AGC TGC ATC          2825
Lys Pro Gly Met Val Phe Ser Ile Ser Arg Gly Ile Tyr Ser Cys Ile
            860                 865                 870

CAT GGG GTG GCG ATC GAG GAG CGC CAG TCT GTA ATG AAC TCC CCC ACC          2873
His Gly Val Ala Ile Glu Glu Arg Gln Ser Val Met Asn Ser Pro Thr
        875                 880                 885

GCA ACC ATG AAC AAC ACA CAC TCC AAC ATC CTG CGC CTG CTG CGC ACG          2921
Ala Thr Met Asn Asn Thr His Ser Asn Ile Leu Arg Leu Leu Arg Thr
    890                 895                 900

GCC AAG AAC ATG GCT AAC CTG TCT GGT GTG AAT GGC TCA CCG CAG AGC          2969
Ala Lys Asn Met Ala Asn Leu Ser Gly Val Asn Gly Ser Pro Gln Ser
905                 910                 915                 920

GCC CTG GAC TTC ATC CGA CGG GAG TCA TCC GTC TAT GAC ATC TCA GAG          3017
Ala Leu Asp Phe Ile Arg Arg Glu Ser Ser Val Tyr Asp Ile Ser Glu
                925                 930                 935

CAC CGC CGC AGC TTC ACG CAT TCT GAC TGC AAA TCC TAC AAC AAC CCG          3065
His Arg Arg Ser Phe Thr His Ser Asp Cys Lys Ser Tyr Asn Asn Pro
            940                 945                 950
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CCC TGT GAG GAG AAC CTC TTC AGT GAC TAC ATC AGT GAG GTA GAG AGA      3113
Pro Cys Glu Glu Asn Leu Phe Ser Asp Tyr Ile Ser Glu Val Glu Arg
        955                 960                 965

ACG TTC GGG AAC CTG CAG CTG AAG GAC AGC AAC GTG TAC CAA GAT CAC      3161
Thr Phe Gly Asn Leu Gln Leu Lys Asp Ser Asn Val Tyr Gln Asp His
    970                 975                 980

TAC CAC CAT CAC CAC CGG CCC CAT AGT ATT GGC AGT GCC AGC TCC ATC      3209
Tyr His His His His Arg Pro His Ser Ile Gly Ser Ala Ser Ser Ile
985                 990                 995                 1000

GAT GGG CTC TAC GAC TGT GAC AAC CCA CCC TTC ACC ACC CAG TCC AGG      3257
Asp Gly Leu Tyr Asp Cys Asp Asn Pro Pro Phe Thr Thr Gln Ser Arg
                1005                1010                1015

TCC ATC AGC AAG AAG CCC CTG GAC ATC GGC CTC CCC TCC TCC AAG CAC      3305
Ser Ile Ser Lys Lys Pro Leu Asp Ile Gly Leu Pro Ser Ser Lys His
            1020                1025                1030

AGC CAG CTC AGT GAC CTG TAC GGC AAA TTC TCC TTC AAG AGC GAC CGC      3353
Ser Gln Leu Ser Asp Leu Tyr Gly Lys Phe Ser Phe Lys Ser Asp Arg
        1035                1040                1045

TAC AGT GGC CAC GAC GAC TTG ATC CGC TCC GAT GTC TCT GAC ATC TCA      3401
Tyr Ser Gly His Asp Asp Leu Ile Arg Ser Asp Val Ser Asp Ile Ser
    1050                1055                1060

ACC CAC ACC GTC ACC TAT GGG AAC ATC GAG GGC AAT GCC GCC AAG AGG      3449
Thr His Thr Val Thr Tyr Gly Asn Ile Glu Gly Asn Ala Ala Lys Arg
1065                1070                1075                1080

CGT AAG CAG CAA TAT AAG GAC AGC CTG AAG AAG CGG CCT GCC TCG GCC      3497
Arg Lys Gln Gln Tyr Lys Asp Ser Leu Lys Lys Arg Pro Ala Ser Ala
                1085                1090                1095

AAG TCC CGC AGG GAG TTT GAC GAG ATC GAG CTG GCC TAC CGT CGC CGA      3545
Lys Ser Arg Arg Glu Phe Asp Glu Ile Glu Leu Ala Tyr Arg Arg Arg
            1100                1105                1110

CCG CCC CGC TCC CCT GAC CAC AAG CGC TAC TTC AGG GAC AAG GAA GGG      3593
Pro Pro Arg Ser Pro Asp His Lys Arg Tyr Phe Arg Asp Lys Glu Gly
        1115                1120                1125

CTA CGG GAC TTC TAC CTG GAC CAG TTC CGA ACA AAG GAG AAC TCA CCC      3641
Leu Arg Asp Phe Tyr Leu Asp Gln Phe Arg Thr Lys Glu Asn Ser Pro
    1130                1135                1140

CAC TGG GAG CAC GTA GAC CTG ACC GAC ATC TAC AAG GAG CGG AGT GAT      3689
His Trp Glu His Val Asp Leu Thr Asp Ile Tyr Lys Glu Arg Ser Asp
1145                1150                1155                1160

GAC TTT AAG CGC GAC TCC ATC AGC GGA GGA GGG CCC TGT ACC AAC AGG      3737
Asp Phe Lys Arg Asp Ser Ile Ser Gly Gly Gly Pro Cys Thr Asn Arg
                1165                1170                1175

TCT CAC ATC AAG CAC GGG ACG GGC GAC AAA CAC GGC GTG GTC AGC GGG      3785
Ser His Ile Lys His Gly Thr Gly Asp Lys His Gly Val Val Ser Gly
            1180                1185                1190

GTA CCT GCA CCT TGG GAG AAG AAC CTG ACC AAC GTG GAG TGG GAG GAC      3833
Val Pro Ala Pro Trp Glu Lys Asn Leu Thr Asn Val Glu Trp Glu Asp
        1195                1200                1205

CGG TCC GGG GGC AAC TTC TGC CGC AGC TGT CCC TCC AAG CTG CAC AAC      3881
Arg Ser Gly Gly Asn Phe Cys Arg Ser Cys Pro Ser Lys Leu His Asn
    1210                1215                1220
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TAC TCC ACG ACG GTG ACG GGT CAG AAC TCG GCC AGG CAG GCG TGC ATC      3929
Tyr Ser Thr Thr Val Thr Gly Gln Asn Ser Gly Arg Gln Ala Cys Ile
1225                1230                1235                1240

CGG TGT GAG GCT TGC AAG AAA GCA GGC AAC CTG TAT GAC ATC AGT GAG      3977
Arg Cys Glu Ala Cys Lys Lys Ala Gly Asn Leu Tyr Asp Ile Ser Glu
                1245                1250                1255

GAC AAC TCC CTG CAG GAA CTG GAC CAG CCG GCT GCC CCA GTG GCG GTG      4025
Asp Asn Ser Leu Gln Glu Leu Asp Gln Pro Ala Ala Pro Val Ala Val
            1260                1265                1270

ACG TCA AAC GCC TCC ACC ACT AAG TAC CCT CAG AGC CCG ACT AAT TCC      4073
Thr Ser Asn Ala Ser Thr Thr Lys Tyr Pro Gln Ser Pro Thr Asn Ser
        1275                1280                1285

AAG GCC CAG AAG AAG AAC CGG AAC AAA CTG CGC CGG CAG CAC TCC TAC      4121
Lys Ala Gln Lys Lys Asn Arg Asn Lys Leu Arg Arg Gln His Ser Tyr
    1290                1295                1300

GAC ACC TTC GTG GAC CTG CAG AAG GAA GAA GCC GCC CTG GCC CCG CGC      4169
Asp Thr Phe Val Asp Leu Gln Lys Glu Glu Ala Ala Leu Ala Pro Arg
1305                1310                1315                1320

AGC GTA AGC CTG AAA GAC AAG GGC CGA TTC ATG GAT GGG AGC CCC TAC      4217
Ser Val Ser Leu Lys Asp Lys Gly Arg Phe Met Asp Gly Ser Pro Tyr
                1325                1330                1335

GCC CAC ATG TTT GAG ATG TCA GCT GGC GAG AGC ACC TTT GCC AAC AAC      4265
Ala His Met Phe Glu Met Ser Ala Gly Glu Ser Thr Phe Ala Asn Asn
            1340                1345                1350

AAG TCC TCA GTG CCC ACT GCC GGA CAT CAC CAC CAC AAC AAC CCC GGC      4313
Lys Ser Ser Val Pro Thr Ala Gly His His His His Asn Asn Pro Gly
        1355                1360                1365

GGC GGG TAC ATG CTC AGC AAG TCG CTC TAC CCT GAC CGG GTC ACG CAA      4361
Gly Gly Tyr Met Leu Ser Lys Ser Leu Tyr Pro Asp Arg Val Thr Gln
    1370                1375                1380

AAC CCT TTC ATC CCC ACT TTT GGG GAC GAC CAG TGC TTG CTC CAT GGC      4409
Asn Pro Phe Ile Pro Thr Phe Gly Asp Asp Gln Cys Leu Leu His Gly
1385                1390                1395                1400

AGC AAA TCC TAC TTC TTC AGG CAG CCC ACG GTG GCG GGG GCG TCG AAA      4457
Ser Lys Ser Tyr Phe Phe Arg Gln Pro Thr Val Ala Gly Ala Ser Lys
                1405                1410                1415

GCC AGG CCG GAC TTC CGG GCC CTT GTC ACC AAC AAG CCG GTG GTC TCG      4505
Ala Arg Pro Asp Phe Arg Ala Leu Val Thr Asn Lys Pro Val Val Ser
            1420                1425                1430

GCC CTT CAT GGG GCC GTG CCA GCC CGT TTC CAG AAG GAC ATC TGT ATA      4553
Ala Leu His Gly Ala Val Pro Ala Arg Phe Gln Lys Asp Ile Cys Ile
        1435                1440                1445

GGG AAC CAG TCC AAC CCC TGT GTG CCT AAC AAC ACA AAC CCC AGG GCT      4601
Gly Asn Gln Ser Asn Pro Cys Val Pro Asn Asn Thr Asn Pro Arg Ala
    1450                1455                1460

TTC AAT GGC TCC AGC AAT GGG CAT GTT TAT GAG AAA CTT TCT AGT ATT      4649
Phe Asn Gly Ser Ser Asn Gly His Val Tyr Glu Lys Leu Ser Ser Ile
1465                1470                1475                1480

GAG TCT GAT GTC TGAGTGAGGG AACAGAGAGG TTAAGGTGGG TACGGGAGGG         4701
Glu Ser Asp Val
                148
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TAAGGCTGTG GGTCGCGTGA TGCGCATGTC ACGGAGGGTG ACGGGGGTGA ACTTGGTTCC 4761

CATTTGCTCC TTTCTTGTTT TAATTTATTT ATGGGATCCT GGAGTTCTGG TTCCTACTGG 4821

GGGCAACCCT GGTGACCAGC ACCATCTCTC CTCCTTTTCA CAGTTCTCTC CTTCTTCCCC 4881

CCGCTGTCAG CCATTCCTGT TCCCATGAGA TGATGCCATG GGCCCTCTCA GCAGGGGAGG 4941

GTAGAGCGGA GAAAGGAAGG GCTGCATGCG GGCTTCCTCC TGGTGTGGAA GAGCTCCTTG 5001

ATATCCTCTT TGAGTGAAGC TGGGAGAACC AAAAAGAGGC TATGTGAGCA CAAAGGTAGC 5061

TTTTCCCAAA CTGATCTTTT CATTTAGGTG AGGAAGCAAA AGCATCTATG TGAGACCATT 5121

TAGCACACTG CTTGTGAAAG GAAAGAGGCT CTGGCTAAAT TCATGCTGCT TAGATGACAT 5181

CTGTCTAGGA ATCATGTGCC AAGCAGAGGT TGGGAGGCCA TTTGTGTTTA TATATAAGCC 5241

CAAAAATGCT TGCTTCAACC CCATGAGACT CGATAGTGGT GGTGAACAGA ACCCAAGGTC 5301

ATTGGTGGCA GAGTGGATTC TTGAACAAAC TGGAAAGTAC GTTATGATAG TGTCCCCCGG 5361

TGCCTTGGGG ACAAGAGCAG GTGGATTGTG CGTGCATGTG TGTTCATGCA CACTTGCACC 5421

CATGTGTAGT CAGGTGCCTC AAGAGAAGGC AACCTTGACT CTTTCGTTGA ATTTGCATCT 5481

CTTCAAGACA CAAGATTAAA ACAAAATTTA CGCTAAATTG GATTTTAAAT TATCTTC 5538

(2) INFORMATION FOR SEQ ID NO:14:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1484 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

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Met Lys Pro Arg Ala Glu Cys Cys Ser Pro Lys Phe Trp Leu Val Leu
 1               5                  10                  15

Ala Val Leu Ala Val Ser Gly Ser Arg Ala Arg Ser Gln Lys Ser Pro
            20                  25                  30

Pro Ser Ile Gly Ile Ala Val Ile Leu Val Gly Thr Ser Asp Glu Val
        35                  40                  45

Ala Ile Lys Asp Ala His Glu Lys Asp Asp Phe His His Leu Ser Val
    50                  55                  60

Val Pro Arg Val Glu Leu Val Ala Met Asn Glu Thr Asp Pro Lys Ser
65                  70                  75                  80

Ile Ile Thr Arg Ile Cys Asp Leu Met Ser Asp Arg Lys Ile Gln Gly
                85                  90                  95

Val Val Phe Ala Asp Asp Thr Asp Gln Glu Ala Ile Ala Gln Ile Leu
            100                 105                 110

Asp Phe Ile Ser Ala Gln Thr Leu Thr Pro Ile Leu Gly Ile His Gly
        115                 120                 125

Gly Ser Ser Met Ile Met Ala Asp Lys Asp Glu Ser Ser Met Phe Phe
    130                 135                 140
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Gln Phe Gly Pro Ser Ile Glu Gln Gln Ala Ser Val Met Leu Asn Ile
145                 150                 155                 160

Met Glu Glu Tyr Asp Trp Tyr Ile Phe Ser Ile Val Thr Thr Tyr Phe
                165                 170                 175

Pro Gly Tyr Gln Asp Phe Val Asn Lys Ile Arg Ser Thr Ile Glu Asn
            180                 185                 190

Ser Phe Val Gly Trp Glu Leu Glu Glu Val Leu Leu Leu Asp Met Ser
        195                 200                 205

Leu Asp Asp Gly Asp Ser Lys Ile Gln Asn Gln Leu Lys Lys Leu Gln
    210                 215                 220

Ser Pro Ile Ile Leu Leu Tyr Cys Thr Lys Glu Glu Ala Thr Tyr Ile
225                 230                 235                 240

Phe Glu Val Ala Asn Ser Val Gly Leu Thr Gly Tyr Gly Tyr Thr Trp
                245                 250                 255

Ile Val Pro Ser Leu Val Ala Gly Asp Thr Asp Thr Val Pro Ala Glu
            260                 265                 270

Phe Pro Thr Gly Leu Ile Ser Val Ser Tyr Asp Glu Trp Asp Tyr Gly
        275                 280                 285

Leu Pro Pro Arg Val Arg Asp Gly Ile Ala Ile Ile Thr Thr Ala Ala
    290                 295                 300

Ser Asp Met Leu Ser Glu His Ser Phe Ile Pro Glu Pro Lys Ser Ser
305                 310                 315                 320

Cys Tyr Asn Thr His Glu Lys Arg Ile Tyr Gln Ser Asn Met Leu Asn
                325                 330                 335

Arg Tyr Leu Ile Asn Val Thr Phe Glu Gly Arg Asn Leu Ser Phe Ser
            340                 345                 350

Glu Asp Gly Tyr Gln Met His Pro Lys Leu Val Ile Ile Leu Leu Asn
        355                 360                 365

Lys Glu Arg Lys Trp Glu Arg Val Gly Lys Trp Lys Asp Lys Ser Leu
    370                 375                 380

Gln Met Lys Tyr Tyr Val Trp Pro Arg Met Cys Pro Glu Thr Glu Glu
385                 390                 395                 400

Gln Glu Asp Asp His Leu Ser Ile Val Thr Leu Glu Glu Ala Pro Phe
                405                 410                 415

Val Ile Val Glu Ser Val Asp Pro Leu Ser Gly Thr Cys Met Arg Asn
            420                 425                 430

Thr Val Pro Cys Gln Lys Arg Ile Val Thr Glu Asn Lys Thr Asp Glu
        435                 440                 445

Glu Pro Gly Tyr Ile Lys Lys Cys Cys Lys Gly Phe Cys Ile Asp Ile
    450                 455                 460

Leu Lys Lys Ile Ser Lys Ser Val Lys Phe Thr Tyr Asp Leu Tyr Leu
465                 470                 475                 480

Val Thr Asn Gly Lys His Gly Lys Lys Ile Asn Gly Thr Trp Asn Gly
                485                 490                 495
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Met Ile Gly Glu Val Val Met Lys Arg Ala Tyr Met Ala Val Gly Ser
500 505 510

Leu Thr Ile Asn Glu Glu Arg Ser Glu Val Val Asp Phe Ser Val Pro
515 520 525

Phe Ile Glu Thr Gly Ile Ser Val Met Val Ser Arg Ser Asn Gly Thr
530 535 540

Val Ser Pro Ser Ala Phe Leu Glu Pro Phe Ser Ala Asp Val Trp Val
545 550 555 560

Met Met Phe Val Met Leu Leu Ile Val Ser Ala Val Ala Val Phe Val
565 570 575

Phe Glu Tyr Phe Ser Pro Val Gly Tyr Asn Arg Cys Leu Ala Asp Gly
580 585 590

Arg Glu Pro Gly Gly Pro Ser Phe Thr Ile Gly Lys Ala Ile Trp Leu
595 600 605

Leu Trp Gly Leu Val Phe Asn Asn Ser Val Pro Val Gln Asn Pro Lys
610 615 620

Gly Thr Thr Ser Lys Ile Met Val Ser Val Trp Ala Phe Phe Ala Val
625 630 635 640

Ile Phe Leu Ala Ser Tyr Thr Ala Asn Leu Ala Ala Phe Met Ile Gln
645 650 655

Glu Glu Tyr Val Asp Gln Val Ser Gly Leu Ser Asp Lys Lys Phe Gln
660 665 670

Arg Pro Asn Asp Phe Ser Pro Pro Phe Arg Phe Gly Thr Val Pro Asn
675 680 685

Gly Ser Thr Glu Arg Asn Ile Arg Asn Asn Tyr Ala Glu Met His Ala
690 695 700

Tyr Met Gly Lys Phe Asn Gln Arg Gly Val Asp Asp Ala Leu Leu Ser
705 710 715 720

Leu Lys Thr Gly Lys Leu Asp Ala Phe Ile Tyr Asp Ala Ala Val Leu
725 730 735

Asn Tyr Met Ala Gly Arg Asp Glu Gly Cys Lys Leu Val Thr Ile Gly
740 745 750

Ser Gly Lys Val Phe Ala Ser Thr Gly Tyr Gly Ile Ala Ile Gln Lys
755 760 765

Asp Ser Gly Trp Lys Arg Gln Val Asp Leu Ala Ile Leu Gln Leu Phe
770 775 780

Gly Asp Gly Glu Met Glu Glu Leu Glu Ala Leu Trp Leu Thr Gly Ile
785 790 795 800

Cys His Asn Glu Lys Asn Glu Val Met Ser Ser Gln Leu Asp Ile Asp
805 810 815

Asn Met Ala Gly Val Phe Tyr Met Leu Gly Ala Ala Met Ala Leu Ser
820 825 830

Leu Ile Thr Phe Ile Cys Glu His Leu Phe Tyr Trp Gln Phe Arg His
835 840 845

Cys Phe Met Gly Val Cys Ser Gly Lys Pro Gly Met Val Phe Ser Ile
850 855 860

Ser Arg Gly Ile Tyr Ser Cys Ile His Gly Val Ala Ile Glu Glu Arg
865 870 875 880

Gln Ser Val Met Asn Ser Pro Thr Ala Thr Met Asn Asn Thr His Ser
885 890 895

Asn Ile Leu Arg Leu Leu Arg Thr Ala Lys Asn Met Ala Asn Leu Ser
900 905 910

Gly Val Asn Gly Ser Pro Gln Ser Ala Leu Asp Phe Ile Arg Arg Glu
915 920 925

Ser Ser Val Tyr Asp Ile Ser Glu His Arg Arg Ser Phe Thr His Ser
930 935 940

Asp Cys Lys Ser Tyr Asn Asn Pro Pro Cys Glu Glu Asn Leu Phe Ser
945 950 955 960

Asp Tyr Ile Ser Glu Val Glu Arg Thr Phe Gly Asn Leu Gln Leu Lys
965 970 975

Asp Ser Asn Val Tyr Gln Asp His Tyr His His His His Arg Pro His
980 985 990

Ser Ile Gly Ser Ala Ser Ser Ile Asp Gly Leu Tyr Asp Cys Asp Asn
995 1000 1005

Pro Pro Phe Thr Thr Gln Ser Arg Ser Ile Ser Lys Lys Pro Leu Asp
1010 1015 1020

Ile Gly Leu Pro Ser Ser Lys His Ser Gln Leu Ser Asp Leu Tyr Gly
1025 1030 1035 1040

Lys Phe Ser Phe Lys Ser Asp Arg Tyr Ser Gly His Asp Asp Leu Ile
1045 1050 1055

Arg Ser Asp Val Ser Asp Ile Ser Thr His Thr Val Thr Tyr Gly Asn
1060 1065 1070

Ile Glu Gly Asn Ala Ala Lys Arg Arg Lys Gln Gln Tyr Lys Asp Ser
1075 1080 1085

Leu Lys Lys Arg Pro Ala Ser Ala Lys Ser Arg Arg Glu Phe Asp Glu
1090 1095 1100

Ile Glu Leu Ala Tyr Arg Arg Arg Pro Pro Arg Ser Pro Asp His Lys
1105 1110 1115 1120

Arg Tyr Phe Arg Asp Lys Glu Gly Leu Arg Asp Phe Tyr Leu Asp Gln
1125 1130 1135

Phe Arg Thr Lys Glu Asn Ser Pro His Trp Glu His Val Asp Leu Thr
1140 1145 1150

Asp Ile Tyr Lys Glu Arg Ser Asp Asp Phe Lys Arg Asp Ser Ile Ser
1155 1160 1165

Gly Gly Gly Pro Cys Thr Asn Arg Ser His Ile Lys His Gly Thr Gly
1170 1175 1180

Asp Lys His Gly Val Val Ser Gly Val Pro Ala Pro Trp Glu Lys Asn
1185 1190 1195 1200

Leu Thr Asn Val Glu Trp Glu Asp Arg Ser Gly Gly Asn Phe Cys Arg
1205 1210 1215

Ser Cys Pro Ser Lys Leu His Asn Tyr Ser Thr Thr Val Thr Gly Gln
1220 1225 1230

Asn Ser Gly Arg Gln Ala Cys Ile Arg Cys Glu Ala Cys Lys Lys Ala
1235 1240 1245

Gly Asn Leu Tyr Asp Ile Ser Glu Asp Asn Ser Leu Gln Glu Leu Asp
1250 1255 1260

Gln Pro Ala Ala Pro Val Ala Val Thr Ser Asn Ala Ser Thr Thr Lys
1265 1270 1275 1280

Tyr Pro Gln Ser Pro Thr Asn Ser Lys Ala Gln Lys Lys Asn Arg Asn
1285 1290 1295

Lys Leu Arg Arg Gln His Ser Tyr Asp Thr Phe Val Asp Leu Gln Lys
1300 1305 1310

Glu Glu Ala Ala Leu Ala Pro Arg Ser Val Ser Leu Lys Asp Lys Gly
1315 1320 1325

Arg Phe Met Asp Gly Ser Pro Tyr Ala His Met Phe Glu Met Ser Ala
1330 1335 1340

Gly Glu Ser Thr Phe Ala Asn Asn Lys Ser Ser Val Pro Thr Ala Gly
1345 1350 1355 1360

His His His His Asn Asn Pro Gly Gly Gly Tyr Met Leu Ser Lys Ser
1365 1370 1375

Leu Tyr Pro Asp Arg Val Thr Gln Asn Pro Phe Ile Pro Thr Phe Gly
1380 1385 1390

Asp Asp Gln Cys Leu Leu His Gly Ser Lys Ser Tyr Phe Phe Arg Gln
1395 1400 1405

Pro Thr Val Ala Gly Ala Ser Lys Ala Arg Pro Asp Phe Arg Ala Leu
1410 1415 1420

Val Thr Asn Lys Pro Val Val Ser Ala Leu His Gly Ala Val Pro Ala
1425 1430 1435 1440

Arg Phe Gln Lys Asp Ile Cys Ile Gly Asn Gln Ser Asn Pro Cys Val
1445 1450 1455

Pro Asn Asn Thr Asn Pro Arg Ala Phe Asn Gly Ser Ser Asn Gly His
1460 1465 1470

Val Tyr Glu Lys Leu Ser Ser Ile Glu Ser Asp Val
1475 1480

(2) INFORMATION FOR SEQ ID NO:15:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 4695 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 485..4495

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

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CGAGAACACA GCGAGTGTGT GAGTCCCTCC CGCTCCAGCT CCTCCAAGCC GCGGCCGCCG      60

CCGCCACCCT CGCCCGCAGC CTCCCGCAGC CTCCCTCGGC CACCGGTGTC TGGTGGGGGT     120

GTTGCCTGGG TAGGTCGGCC CGGCCCCCAG GGGTCTCTCG AGCGTCTGCC ATCTGCCCGA     180

GAAACATGTG TGGCCACGTC CTCGCCTAGT CCAGGTGGCC GCAACCTTGG GGGAGAGACA     240

GGGCAGGACA GGACCAAGGT AAGAGGTAAG GAGGAGACGG CGCCAGGGAC AGACAGGAGG     300

TCCCGGCTTG CCGTTGTGCG CACCACCACT GCCGCCGCCC CGGGGCCTGC CCCCGACATC     360

GGCTCTCTGA GCCCTCCTCG GAATCTTGGG GTCGCTGGAC GCCGGGTTCC GGTCCTGGCC     420

CCCCCGCCAT CCCCCCAACA GAACAGGGTC ATGAAAAGAG GCCGCCCGGC GGGGCCCGCA     480

GGCG ATG CGC GGC GCC GGT GGC CCC CGC GGC CCT CGG GGC CCC GCT AAG       529
     Met Arg Gly Ala Gly Gly Pro Arg Gly Pro Arg Gly Pro Ala Lys
       1               5                  10                  15

ATG CTG CTG CTG CTG GCG CTG GCC TGC GCC AGC CCG TTC CCG GAG GAG       577
Met Leu Leu Leu Leu Ala Leu Ala Cys Ala Ser Pro Phe Pro Glu Glu
                  20                  25                  30

GCG CCG GGG CCG GGC GGG GCC GGT GGG CCC GGC GGC GGC CTC GGC GGG       625
Ala Pro Gly Pro Gly Gly Ala Gly Gly Pro Gly Gly Gly Leu Gly Gly
              35                  40                  45

GCG CGG CCG CTC AAC GTG GCG CTC GTG TTC TCG GGG CCC GCG TAC GCG       673
Ala Arg Pro Leu Asn Val Ala Leu Val Phe Ser Gly Pro Ala Tyr Ala
          50                  55                  60

GCC GAG GCG GCA CGC CTG GGC CCG GCC GTG GCG GCG GCG GTG CGC AGC       721
Ala Glu Ala Ala Arg Leu Gly Pro Ala Val Ala Ala Ala Val Arg Ser
      65                  70                  75

CCG GGC CTA GAC GTG CGG CCC GTG GCG CTG GTG CTC AAC GGC TCG GAC       769
Pro Gly Leu Asp Val Arg Pro Val Ala Leu Val Leu Asn Gly Ser Asp
  80                  85                  90                  95

CCG CGC AGC CTC GTG CTG CAG CTC TGC GAC CTG CTG TCG GGG TTG CGC       817
Pro Arg Ser Leu Val Leu Gln Leu Cys Asp Leu Leu Ser Gly Leu Arg
                 100                 105                 110

GTG CAC GGC GTG GTC TTC GAA GAC GAC TCG CGC GCG CCC GCC GTC GCG       865
Val His Gly Val Val Phe Glu Asp Asp Ser Arg Ala Pro Ala Val Ala
             115                 120                 125

CCC ATC CTC GAC TTC CTG TCG GCG CAG ACC TCG CTC CCC ATC GTG TCC       913
Pro Ile Leu Asp Phe Leu Ser Ala Gln Thr Ser Leu Pro Ile Val Ser
         130                 135                 140

GAG CAC GGC GGC GCC GCG CTC GTG CTC ACG CCC AAG GAG AAG GGC TCC       961
Glu His Gly Gly Ala Ala Leu Val Leu Thr Pro Lys Glu Lys Gly Ser
     145                 150                 155

ACC TTC CTC CAC CTG GGC TCT TCC CCC GAG CAA CAG CTT CAG GTC ATC      1009
Thr Phe Leu His Leu Gly Ser Ser Pro Glu Gln Gln Leu Gln Val Ile
160                 165                 170                 175
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TTT GAG GTG CTG GAG GAG TAT GAC TGG ACG TCC TTT GTA GCC GTG ACC      1057
Phe Glu Val Leu Glu Glu Tyr Asp Trp Thr Ser Phe Val Ala Val Thr
                180                 185                 190

ACT CGT GCC CCT GGC CAC CGG GCC TTC CTG TCC TAC ATT GAG GTG CTG      1105
Thr Arg Ala Pro Gly His Arg Ala Phe Leu Ser Tyr Ile Glu Val Leu
            195                 200                 205

ACT GAC GGC AGT CTG GTG GGC TGG GAG CAC CGC GGA GCG CTG ACG CTG      1153
Thr Asp Gly Ser Leu Val Gly Trp Glu His Arg Gly Ala Leu Thr Leu
        210                 215                 220

GAC CCT GGG GCG GGC GAG GCC GTG CTC AGT GCC CAG CTC CGC AGT GTC      1201
Asp Pro Gly Ala Gly Glu Ala Val Leu Ser Ala Gln Leu Arg Ser Val
    225                 230                 235

AGC GCG CAG ATC CGC CTG CTC TTC TGC GCC CGA GAG GAG GCC GAG CCC      1249
Ser Ala Gln Ile Arg Leu Leu Phe Cys Ala Arg Glu Glu Ala Glu Pro
240                 245                 250                 255

GTG TTC CGC GCA GCT GAG GAG GCT GGC CTC ACT GGA TCT GGC TAC GTC      1297
Val Phe Arg Ala Ala Glu Glu Ala Gly Leu Thr Gly Ser Gly Tyr Val
                260                 265                 270

TGG TTC ATG GTG GGG CCC CAG CTG GCT GGA GGC GGG GGC TCT GGG GCC      1345
Trp Phe Met Val Gly Pro Gln Leu Ala Gly Gly Gly Gly Ser Gly Ala
            275                 280                 285

CCT GGT GAG CCC CCT CTT CTG CCA GGA GGC GCC CCC CTG CCT GCC GGG      1393
Pro Gly Glu Pro Pro Leu Leu Pro Gly Gly Ala Pro Leu Pro Ala Gly
        290                 295                 300

CTG TTT GCA GTG CGC TCG GCT GGC TGG CGG GAT GAC CTG GCT CGG CGA      1441
Leu Phe Ala Val Arg Ser Ala Gly Trp Arg Asp Asp Leu Ala Arg Arg
    305                 310                 315

GTG GCA GCT GGC GTG GCC GTA GTG GCC AGA GGT GCC CAG GCC CTG CTG      1489
Val Ala Ala Gly Val Ala Val Val Ala Arg Gly Ala Gln Ala Leu Leu
320                 325                 330                 335

CGT GAT TAT GGT TTC CTT CCT GAG CTC GGC CAC GAC TGT CGC GCC CAG      1537
Arg Asp Tyr Gly Phe Leu Pro Glu Leu Gly His Asp Cys Arg Ala Gln
                340                 345                 350

AAC CGC ACC CAC CGC GGG GAG AGT CTG CAT AGG TAC TTC ATG AAC ATC      1585
Asn Arg Thr His Arg Gly Glu Ser Leu His Arg Tyr Phe Met Asn Ile
            355                 360                 365

ACG TGG GAT AAC CGG GAT TAC TCC TTC AAT GAG GAC GGC TTC CTA GTG      1633
Thr Trp Asp Asn Arg Asp Tyr Ser Phe Asn Glu Asp Gly Phe Leu Val
        370                 375                 380

AAC CCC TCC CTG GTG GTC ATC TCC CTC ACC AGA GAC AGG ACG TGG GAG      1681
Asn Pro Ser Leu Val Val Ile Ser Leu Thr Arg Asp Arg Thr Trp Glu
    385                 390                 395

GTG GTG GGC AGC TGG GAG CAG CAG ACG CTC CGC CTC AAG TAC CCG CTG      1729
Val Val Gly Ser Trp Glu Gln Gln Thr Leu Arg Leu Lys Tyr Pro Leu
400                 405                 410                 415

TGG TCC CGC TAT GGT CGC TTC CTG CAG CCA GTG GAC GAC ACG CAG CAC      1777
Trp Ser Arg Tyr Gly Arg Phe Leu Gln Pro Val Asp Asp Thr Gln His
                420                 425                 430

CTC GCG GTG GCC ACG CTG GAG GAA AGG CCG TTT GTC ATC GTG GAG CCT      1825
Leu Ala Val Ala Thr Leu Glu Glu Arg Pro Phe Val Ile Val Glu Pro
            435                 440                 445
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GCA GAC CCT ATC AGC GGC ACC TGC ATC CGA GAC TCC GTC CCC TGC CGG      1873
Ala Asp Pro Ile Ser Gly Thr Cys Ile Arg Asp Ser Val Pro Cys Arg
        450                 455                 460

AGC CAG CTC AAC CGA ACC CAC AGC CCT CCA CCG GAT GCC CCC CGC CCG      1921
Ser Gln Leu Asn Arg Thr His Ser Pro Pro Pro Asp Ala Pro Arg Pro
    465                 470                 475

GAA AAG CGC TGC TGC AAG GGT TTC TGC ATC GAC ATT CTG AAG CGG CTG      1969
Glu Lys Arg Cys Cys Lys Gly Phe Cys Ile Asp Ile Leu Lys Arg Leu
480                 485                 490                 495

GCG CAT ACC ATC GGC TTC AGC TAC GAC CTC TAC CTG GTC ACC AAT GGC      2017
Ala His Thr Ile Gly Phe Ser Tyr Asp Leu Tyr Leu Val Thr Asn Gly
                500                 505                 510

AAG CAC GGA AAG AAG ATC GAT GGC GTC TGG AAC GGC ATG ATC GGG GAG      2065
Lys His Gly Lys Lys Ile Asp Gly Val Trp Asn Gly Met Ile Gly Glu
            515                 520                 525

GTG TTC TAC CAG CGC GCA GAC ATG GCC ATC GGC TCC CTC ACC ATC AAC      2113
Val Phe Tyr Gln Arg Ala Asp Met Ala Ile Gly Ser Leu Thr Ile Asn
        530                 535                 540

GAG GAG CGC TCC GAG ATC GTG GAC TTC TCC GTC CCC TTC GTG GAG ACC      2161
Glu Glu Arg Ser Glu Ile Val Asp Phe Ser Val Pro Phe Val Glu Thr
    545                 550                 555

GGC ATC AGC GTC ATG GTG GCG CGC AGC AAT GGC ACG GTG TCC CCC TCG      2209
Gly Ile Ser Val Met Val Ala Arg Ser Asn Gly Thr Val Ser Pro Ser
560                 565                 570                 575

GCC TTC CTC GAG CCC TAC AGC CCC GCC GTG TGG GTG ATG ATG TTC GTC      2257
Ala Phe Leu Glu Pro Tyr Ser Pro Ala Val Trp Val Met Met Phe Val
                580                 585                 590

ATG TGC CTC ACT GTG GTC GCC GTC ACT GTT TTC ATC TTC GAG TAC CTC      2305
Met Cys Leu Thr Val Val Ala Val Thr Val Phe Ile Phe Glu Tyr Leu
            595                 600                 605

AGT CCT GTT GGT TAC AAC CGC AGC CTG GCC ACG GGC AAG CGC CCT GGC      2353
Ser Pro Val Gly Tyr Asn Arg Ser Leu Ala Thr Gly Lys Arg Pro Gly
        610                 615                 620

GGT TCA ACC TTC ACC ATT GGG AAA TCC ATC TGG CTG CTC TGG GCC CTG      2401
Gly Ser Thr Phe Thr Ile Gly Lys Ser Ile Trp Leu Leu Trp Ala Leu
    625                 630                 635

GTG TTC AAT AAT TCG GTG CCC GTG GAG AAC CCC CGG GGA ACC ACC AGC      2449
Val Phe Asn Asn Ser Val Pro Val Glu Asn Pro Arg Gly Thr Thr Ser
640                 645                 650                 655

AAA ATC ATG GTG CTG GTG TGG GCC TTC TTC GCC GTC ATC TTC CTC GCC      2497
Lys Ile Met Val Leu Val Trp Ala Phe Phe Ala Val Ile Phe Leu Ala
                660                 665                 670

AGC TAC ACA GCC AAC CTG GCC GCC TTC ATG ATC CAG GAG GAG TAC GTG      2545
Ser Tyr Thr Ala Asn Leu Ala Ala Phe Met Ile Gln Glu Glu Tyr Val
            675                 680                 685

GAT ACT GTG TCT GGG CTC AGT GAC CGC AAG TTC CAG AGG CCC CAG GAG      2593
Asp Thr Val Ser Gly Leu Ser Asp Arg Lys Phe Gln Arg Pro Gln Glu
        690                 695                 700

CAG TAC CCG CCC CTG AAG TTT GGG ACC GTG CCC AAC GGC TCC ACG GAG      2641
Gln Tyr Pro Pro Leu Lys Phe Gly Thr Val Pro Asn Gly Ser Thr Glu
    705                 710                 715
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AAG AAC ATC CGC AGC AAC TAT CCC GAC ATG CAC AGC TAC ATG GTG CGC      2689
Lys Asn Ile Arg Ser Asn Tyr Pro Asp Met His Ser Tyr Met Val Arg
720                 725                 730                 735

TAC AAC CAG CCC CGC GTA GAG GAA GCG CTC ACT CAG CTC AAG GCA GGG      2737
Tyr Asn Gln Pro Arg Val Glu Glu Ala Leu Thr Gln Leu Lys Ala Gly
                740                 745                 750

AAG CTG GAC GCC TTC ATC TAC GAT GCT GCA GTG CTC AAT TAC ATG GCC      2785
Lys Leu Asp Ala Phe Ile Tyr Asp Ala Ala Val Leu Asn Tyr Met Ala
            755                 760                 765

CGC AAG GAC GAG GGC TGC AAG CTT GTC ACC ATC GGC TCC GGC AAG GTC      2833
Arg Lys Asp Glu Gly Cys Lys Leu Val Thr Ile Gly Ser Gly Lys Val
        770                 775                 780

TTC GCC ACG ACA GGC TAT GGC ATC GCC CTG CAC AAG GGC TCC CGC TGG      2881
Phe Ala Thr Thr Gly Tyr Gly Ile Ala Leu His Lys Gly Ser Arg Trp
    785                 790                 795

AAG CGG CCC ATC GAC CTG GCG TTG CTG CAG TTC CTG GGG GAT GAT GAG      2929
Lys Arg Pro Ile Asp Leu Ala Leu Leu Gln Phe Leu Gly Asp Asp Glu
800                 805                 810                 815

ATC GAG ATG CTG GAG CGG CTG TGG CTC TCT GGG ATC TGC CAC AAT GAC      2977
Ile Glu Met Leu Glu Arg Leu Trp Leu Ser Gly Ile Cys His Asn Asp
                820                 825                 830

AAA ATC GAG GTG ATG AGC AGC AAG CTG GAC ATC GAC AAC ATG GCG GGC      3025
Lys Ile Glu Val Met Ser Ser Lys Leu Asp Ile Asp Asn Met Ala Gly
            835                 840                 845

GTC TTC TAC ATG CTC CTG GTG GCC ATG GGC CTG TCC CTG CTG GTC TTC      3073
Val Phe Tyr Met Leu Leu Val Ala Met Gly Leu Ser Leu Leu Val Phe
        850                 855                 860

GCC TGG GAG CAC CTG GTG TAC TGG CGC CTG CGG CAC TGC CTG GGG CCC      3121
Ala Trp Glu His Leu Val Tyr Trp Arg Leu Arg His Cys Leu Gly Pro
    865                 870                 875

ACC CAC CGC ATG GAC TTC CTG CTG GCC TTC TCC AGG GGC ATG TAC AGC      3169
Thr His Arg Met Asp Phe Leu Leu Ala Phe Ser Arg Gly Met Tyr Ser
880                 885                 890                 895

TGC TGC AGC GCT GAG GCC GCC CCA CCG CCC GCC AAG CCC CCG CCG CCG      3217
Cys Cys Ser Ala Glu Ala Ala Pro Pro Pro Ala Lys Pro Pro Pro Pro
                900                 905                 910

CCA CAG CCC CTG CCC AGC CCC GCG TAC CCC GCG CCG GGG CCG GCT CCC      3265
Pro Gln Pro Leu Pro Ser Pro Ala Tyr Pro Ala Pro Gly Pro Ala Pro
            915                 920                 925

GGG CCC GCA CCT TTC GTC CCC CGC GAG CGC GCC TCA GTG GCC CGC TGG      3313
Gly Pro Ala Pro Phe Val Pro Arg Glu Arg Ala Ser Val Ala Arg Trp
        930                 935                 940

CGC CGG CCC AAG GGC GCG GGG CCG CCG GGG GGC GCG GGC CTG GCC GAC      3361
Arg Arg Pro Lys Gly Ala Gly Pro Pro Gly Gly Ala Gly Leu Ala Asp
    945                 950                 955

GGC TTC CAC CGC TAC TAC GGC CCC ATC GAG CCG CAG GGC CTA GGC CTC      3409
Gly Phe His Arg Tyr Tyr Gly Pro Ile Glu Pro Gln Gly Leu Gly Leu
960                 965                 970                 975

GGC CTG GGC GAA GCG CGC GCG GCA CCG CGG GGC GCA GCC GGG CGC CCG      3457
Gly Leu Gly Glu Ala Arg Ala Ala Pro Arg Gly Ala Ala Gly Arg Pro
                980                 985                 990
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CTG TCC CCG CCG GCC GCT CAG CCC CCG CAG AAG CCG CCG GCC TCC TAT      3505
Leu Ser Pro Pro Ala Ala Gln Pro Pro Gln Lys Pro Pro Ala Ser Tyr
            995                1000                1005

TTC GCC ATC GTA CGC GAC AAG GAG CCA GCC GAG CCC CCC GCC GGC GCC      3553
Phe Ala Ile Val Arg Asp Lys Glu Pro Ala Glu Pro Pro Ala Gly Ala
        1010                1015                1020

TTC CCC GGC TTC CCG TCC CCG CCC GCG CCC CCC GCC GCC GCG GCC ACC      3601
Phe Pro Gly Phe Pro Ser Pro Pro Ala Pro Pro Ala Ala Ala Ala Thr
    1025                1030                1035

GCC GTC GGG CCG CCA CTC TGC CGC TTG GCC TTC GAG GAC GAG AGC CCG      3649
Ala Val Gly Pro Pro Leu Cys Arg Leu Ala Phe Glu Asp Glu Ser Pro
1040                1045                1050                1055

CCG GCG CCC GCG CGG TGG CCG CGC TCG GAC CCC GAG AGC CAA CCC CTG      3697
Pro Ala Pro Ala Arg Trp Pro Arg Ser Asp Pro Glu Ser Gln Pro Leu
                1060                1065                1070

CTG GGG CCA GGC GCG GGC GGC GCG GGG GGC ACG GGG GGC GCA GGC GGA      3745
Leu Gly Pro Gly Ala Gly Gly Ala Gly Gly Thr Gly Gly Ala Gly Gly
            1075                1080                1085

GGA GCC CCG GCC GCT CCG CCC CCG TGC TTC GCC GCG CCG CCC CCG TGC      3793
Gly Ala Pro Ala Ala Pro Pro Pro Cys Phe Ala Ala Pro Pro Pro Cys
        1090                1095                1100

TTT TAC CTC GAT GTC GAC CAG TCG CCG TCG GAC TCG GAG GAC TCG GAG      3841
Phe Tyr Leu Asp Val Asp Gln Ser Pro Ser Asp Ser Glu Asp Ser Glu
    1105                1110                1115

AGC CTG GCC GGC GCG TCC CTG GCC GGC CTG GAT CCC TGG TGG TTC GCC      3889
Ser Leu Ala Gly Ala Ser Leu Ala Gly Leu Asp Pro Trp Trp Phe Ala
1120                1125                1130                1135

GAC TTC CCT TAC CCG TAT GCC GAT CGC CTC GGG CSG CCC GCG GCA CGC      3937
Asp Phe Pro Tyr Pro Tyr Ala Asp Arg Leu Gly Xaa Pro Ala Ala Arg
                1140                1145                1150

TAC GGA TTG GTC GAC AAA CTA GGG GGC TGG CTC GCC GGG AGC TGG GAC      3985
Tyr Gly Leu Val Asp Lys Leu Gly Gly Trp Leu Ala Gly Ser Trp Asp
            1155                1160                1165

TAC CTG CCT CCS CGC AGC GGT CGG GCC GCC TGG CAC TGT CGG CAC TGC      4033
Tyr Leu Pro Xaa Arg Ser Gly Arg Ala Ala Trp His Cys Arg His Cys
        1170                1175                1180

GCC AGC CTG GAG CTG CTT CCG CCG CCG CGC CAT CTC AGC TGC TCG CAC      4081
Ala Ser Leu Glu Leu Leu Pro Pro Pro Arg His Leu Ser Cys Ser His
    1185                1190                1195

GAT GGC CTG GAC GGC GGC TGG TGG GCG CCA CCG CCT CCA CCC TGG GCC      4129
Asp Gly Leu Asp Gly Gly Trp Trp Ala Pro Pro Pro Pro Pro Trp Ala
1200                1205                1210                1215

GCC GGG CCC CTG CCC CGA CGC CGG GCC CGC TGC GGG TGC CCG CGG TCG      4177
Ala Gly Pro Leu Pro Arg Arg Arg Ala Arg Cys Gly Cys Pro Arg Ser
                1220                1225                1230

CAC CCG CAC CGC CCG CGG GCC TCG CAC CGC ACG CCC GCC GCT GCC GCG      4225
His Pro His Arg Pro Arg Ala Ser His Arg Thr Pro Ala Ala Ala Ala
            1235                1240                1245

CCC CAC CAC CAC AGG CAC CGG CGC GCC GCT GGG GGC TGG GAC CTC CCG      4273
Pro His His His Arg His Arg Arg Ala Ala Gly Gly Trp Asp Leu Pro
        1250                1255                1260
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CCG CCC GCG CCC ACC TCG CGC TCG CTC GAG GAC CTC AGC TCG TGC CCT      4321
Pro Pro Ala Pro Thr Ser Arg Ser Leu Glu Asp Leu Ser Ser Cys Pro
    1265                1270                1275

CGC GCC GCC CCT GCG CGC AGG CTT ACC GGG CCC TCC CGC CAC GCT CGC      4369
Arg Ala Ala Pro Ala Arg Arg Leu Thr Gly Pro Ser Arg His Ala Arg
1280                1285                1290                1295

AGG TGT CCG CAC GCC GCG CAC TGG GGG CCG CCG CTG CCT ACA GCT TCC      4417
Arg Cys Pro His Ala Ala His Trp Gly Pro Pro Leu Pro Thr Ala Ser
                1300                1305                1310

CAC CGG AGA CAC CGG GGC GGG GAC CTG GGC ACC CGC AGG GGC TCG GCG      4465
His Arg Arg His Arg Gly Gly Asp Leu Gly Thr Arg Arg Gly Ser Ala
            1315                1320                1325

CAC TTC TCT AGC CTC GAG TCC GAG GTA TGACGCGGCC CCGGGGGCCC            4512
His Phe Ser Ser Leu Glu Ser Glu Val
        1330                1335

CACCGCCCCC TTGGTCAGCG CAGGCCACGG CCCGAGGGGG CGCCCGCAGT GGACAGGACC    4572

CGCGTGGGTT GGGAAGGAAA GCAGTGGAAC TGGCCGGACC CCGCCTGGAG CAGCGTCCTG    4632

CGCCCCCTGG TTCTGGAGGA ACCGCAAGCC GGAGAGGATT TGGTCCCTCA ACTATCACCC    4692

AGG                                                                  4695
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(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1336 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

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Met Arg Gly Ala Gly Gly Pro Arg Gly Pro Arg Gly Pro Ala Lys Met
  1               5                  10                  15

Leu Leu Leu Leu Ala Leu Ala Cys Ala Ser Pro Phe Pro Glu Glu Ala
            20                  25                  30

Pro Gly Pro Gly Gly Ala Gly Gly Pro Gly Gly Gly Leu Gly Gly Ala
        35                  40                  45

Arg Pro Leu Asn Val Ala Leu Val Phe Ser Gly Pro Ala Tyr Ala Ala
    50                  55                  60

Glu Ala Ala Arg Leu Gly Pro Ala Val Ala Ala Ala Val Arg Ser Pro
65                  70                  75                  80

Gly Leu Asp Val Arg Pro Val Ala Leu Val Leu Asn Gly Ser Asp Pro
                85                  90                  95

Arg Ser Leu Val Leu Gln Leu Cys Asp Leu Leu Ser Gly Leu Arg Val
            100                 105                 110

His Gly Val Val Phe Glu Asp Asp Ser Arg Ala Pro Ala Val Ala Pro
        115                 120                 125

Ile Leu Asp Phe Leu Ser Ala Gln Thr Ser Leu Pro Ile Val Ser Glu
    130                 135                 140
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His Gly Gly Ala Ala Leu Val Leu Thr Pro Lys Glu Lys Gly Ser Thr
145 150 155 160

Phe Leu His Leu Gly Ser Ser Pro Glu Gln Gln Leu Gln Val Ile Phe
165 170 175

Glu Val Leu Glu Glu Tyr Asp Trp Thr Ser Phe Val Ala Val Thr Thr
180 185 190

Arg Ala Pro Gly His Arg Ala Phe Leu Ser Tyr Ile Glu Val Leu Thr
195 200 205

Asp Gly Ser Leu Val Gly Trp Glu His Arg Gly Ala Leu Thr Leu Asp
210 215 220

Pro Gly Ala Gly Glu Ala Val Leu Ser Ala Gln Leu Arg Ser Val Ser
225 230 235 240

Ala Gln Ile Arg Leu Leu Phe Cys Ala Arg Glu Glu Ala Glu Pro Val
245 250 255

Phe Arg Ala Ala Glu Glu Ala Gly Leu Thr Gly Ser Gly Tyr Val Trp
260 265 270

Phe Met Val Gly Pro Gln Leu Ala Gly Gly Gly Gly Ser Gly Ala Pro
275 280 285

Gly Glu Pro Pro Leu Leu Pro Gly Gly Ala Pro Leu Pro Ala Gly Leu
290 295 300

Phe Ala Val Arg Ser Ala Gly Trp Arg Asp Asp Leu Ala Arg Arg Val
305 310 315 320

Ala Ala Gly Val Ala Val Val Ala Arg Gly Ala Gln Ala Leu Leu Arg
325 330 335

Asp Tyr Gly Phe Leu Pro Glu Leu Gly His Asp Cys Arg Ala Gln Asn
340 345 350

Arg Thr His Arg Gly Glu Ser Leu His Arg Tyr Phe Met Asn Ile Thr
355 360 365

Trp Asp Asn Arg Asp Tyr Ser Phe Asn Glu Asp Gly Phe Leu Val Asn
370 375 380

Pro Ser Leu Val Val Ile Ser Leu Thr Arg Asp Arg Thr Trp Glu Val
385 390 395 400

Val Gly Ser Trp Glu Gln Gln Thr Leu Arg Leu Lys Tyr Pro Leu Trp
405 410 415

Ser Arg Tyr Gly Arg Phe Leu Gln Pro Val Asp Asp Thr Gln His Leu
420 425 430

Ala Val Ala Thr Leu Glu Glu Arg Pro Phe Val Ile Val Glu Pro Ala
435 440 445

Asp Pro Ile Ser Gly Thr Cys Ile Arg Asp Ser Val Pro Cys Arg Ser
450 455 460

Gln Leu Asn Arg Thr His Ser Pro Pro Pro Asp Ala Pro Arg Pro Glu
465 470 475 480

Lys Arg Cys Cys Lys Gly Phe Cys Ile Asp Ile Leu Lys Arg Leu Ala
485 490 495

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His Thr Ile Gly Phe Ser Tyr Asp Leu Tyr Leu Val Thr Asn Gly Lys
            500                 505                 510

His Gly Lys Lys Ile Asp Gly Val Trp Asn Gly Met Ile Gly Glu Val
        515                 520                 525

Phe Tyr Gln Arg Ala Asp Met Ala Ile Gly Ser Leu Thr Ile Asn Glu
    530                 535                 540

Glu Arg Ser Glu Ile Val Asp Phe Ser Val Pro Phe Val Glu Thr Gly
545                 550                 555                 560

Ile Ser Val Met Val Ala Arg Ser Asn Gly Thr Val Ser Pro Ser Ala
                565                 570                 575

Phe Leu Glu Pro Tyr Ser Pro Ala Val Trp Val Met Met Phe Val Met
            580                 585                 590

Cys Leu Thr Val Val Ala Val Thr Val Phe Ile Phe Glu Tyr Leu Ser
        595                 600                 605

Pro Val Gly Tyr Asn Arg Ser Leu Ala Thr Gly Lys Arg Pro Gly Gly
    610                 615                 620

Ser Thr Phe Thr Ile Gly Lys Ser Ile Trp Leu Leu Trp Ala Leu Val
625                 630                 635                 640

Phe Asn Asn Ser Val Pro Val Glu Asn Pro Arg Gly Thr Thr Ser Lys
                645                 650                 655

Ile Met Val Leu Val Trp Ala Phe Phe Ala Val Ile Phe Leu Ala Ser
            660                 665                 670

Tyr Thr Ala Asn Leu Ala Ala Phe Met Ile Gln Glu Glu Tyr Val Asp
        675                 680                 685

Thr Val Ser Gly Leu Ser Asp Arg Lys Phe Gln Arg Pro Gln Glu Gln
    690                 695                 700

Tyr Pro Pro Leu Lys Phe Gly Thr Val Pro Asn Gly Ser Thr Glu Lys
705                 710                 715                 720

Asn Ile Arg Ser Asn Tyr Pro Asp Met His Ser Tyr Met Val Arg Tyr
                725                 730                 735

Asn Gln Pro Arg Val Glu Glu Ala Leu Thr Gln Leu Lys Ala Gly Lys
            740                 745                 750

Leu Asp Ala Phe Ile Tyr Asp Ala Ala Val Leu Asn Tyr Met Ala Arg
        755                 760                 765

Lys Asp Glu Gly Cys Lys Leu Val Thr Ile Gly Ser Gly Lys Val Phe
    770                 775                 780

Ala Thr Thr Gly Tyr Gly Ile Ala Leu His Lys Gly Ser Arg Trp Lys
785                 790                 795                 800

Arg Pro Ile Asp Leu Ala Leu Leu Gln Phe Leu Gly Asp Asp Glu Ile
                805                 810                 815

Glu Met Leu Glu Arg Leu Trp Leu Ser Gly Ile Cys His Asn Asp Lys
            820                 825                 830

Ile Glu Val Met Ser Ser Lys Leu Asp Ile Asp Asn Met Ala Gly Val
        835                 840                 845
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Phe Tyr Met Leu Leu Val Ala Met Gly Leu Ser Leu Leu Val Phe Ala
850 855 860

Trp Glu His Leu Val Tyr Trp Arg Leu Arg His Cys Leu Gly Pro Thr
865 870 875 880

His Arg Met Asp Phe Leu Leu Ala Phe Ser Arg Gly Met Tyr Ser Cys
885 890 895

Cys Ser Ala Glu Ala Ala Pro Pro Pro Ala Lys Pro Pro Pro Pro Pro
900 905 910

Gln Pro Leu Pro Ser Pro Ala Tyr Pro Ala Pro Gly Pro Ala Pro Gly
915 920 925

Pro Ala Pro Phe Val Pro Arg Glu Arg Ala Ser Val Ala Arg Trp Arg
930 935 940

Arg Pro Lys Gly Ala Gly Pro Pro Gly Gly Ala Gly Leu Ala Asp Gly
945 950 955 960

Phe His Arg Tyr Tyr Gly Pro Ile Glu Pro Gln Gly Leu Gly Leu Gly
965 970 975

Leu Gly Glu Ala Arg Ala Ala Pro Arg Gly Ala Ala Gly Arg Pro Leu
980 985 990

Ser Pro Pro Ala Ala Gln Pro Pro Gln Lys Pro Pro Ala Ser Tyr Phe
995 1000 1005

Ala Ile Val Arg Asp Lys Glu Pro Ala Glu Pro Pro Ala Gly Ala Phe
1010 1015 1020

Pro Gly Phe Pro Ser Pro Pro Ala Pro Pro Ala Ala Ala Ala Thr Ala
1025 1030 1035 1040

Val Gly Pro Pro Leu Cys Arg Leu Ala Phe Glu Asp Glu Ser Pro Pro
1045 1050 1055

Ala Pro Ala Arg Trp Pro Arg Ser Asp Pro Glu Ser Gln Pro Leu Leu
1060 1065 1070

Gly Pro Gly Ala Gly Gly Ala Gly Gly Thr Gly Gly Ala Gly Gly Gly
1075 1080 1085

Ala Pro Ala Ala Pro Pro Pro Cys Phe Ala Ala Pro Pro Pro Cys Phe
1090 1095 1100

Tyr Leu Asp Val Asp Gln Ser Pro Ser Asp Ser Glu Asp Ser Glu Ser
1105 1110 1115 1120

Leu Ala Gly Ala Ser Leu Ala Gly Leu Asp Pro Trp Trp Phe Ala Asp
1125 1130 1135

Phe Pro Tyr Pro Tyr Ala Asp Arg Leu Gly Xaa Pro Ala Ala Arg Tyr
1140 1145 1150

Gly Leu Val Asp Lys Leu Gly Gly Trp Leu Ala Gly Ser Trp Asp Tyr
1155 1160 1165

Leu Pro Xaa Arg Ser Gly Arg Ala Ala Trp His Cys Arg His Cys Ala
1170 1175 1180

Ser Leu Glu Leu Leu Pro Pro Pro Arg His Leu Ser Cys Ser His Asp
1185 1190 1195 1200

Gly Leu Asp Gly Gly Trp Trp Ala Pro Pro Pro Pro Trp Ala Ala
1205 1210 1215

Gly Pro Leu Pro Arg Arg Arg Ala Arg Cys Gly Cys Pro Arg Ser His
1220 1225 1230

Pro His Arg Pro Arg Ala Ser His Arg Thr Pro Ala Ala Ala Ala Pro
1235 1240 1245

His His His Arg His Arg Arg Ala Ala Gly Gly Trp Asp Leu Pro Pro
1250 1255 1260

Pro Ala Pro Thr Ser Arg Ser Leu Glu Asp Leu Ser Ser Cys Pro Arg
1265 1270 1275 1280

Ala Ala Pro Ala Arg Arg Leu Thr Gly Pro Ser Arg His Ala Arg Arg
1285 1290 1295

Cys Pro His Ala Ala His Trp Gly Pro Pro Leu Pro Thr Ala Ser His
1300 1305 1310

Arg Arg His Arg Gly Gly Asp Leu Gly Thr Arg Arg Gly Ser Ala His
1315 1320 1325

Phe Ser Ser Leu Glu Ser Glu Val
1330 1335

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 71 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

GGGTGGCGGC CGCAGAGCAC CTCCACCATC TCCTTGTCCT ACTCCAAGAT CTGGCCCTAG 60

TCCATGTTTG C 71

(2) INFORMATION FOR SEQ ID NO:18:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 71 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

TGGTGGTCCC CAACCTGTAG GACTTGGTTC TGGAGGAGGA TCTGGTGTAG GCAAACATGG 60

ACTAGGGCCA G 71

(2) INFORMATION FOR SEQ ID NO:19:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 61 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

GTTGGGGACC ACCAGATGGA GGTAGAGCTG CACTTGTACG AAGAGCTCCA CAACCACCTG 60

G 61

(2) INFORMATION FOR SEQ ID NO:20:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 62 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

CGTGAGACGT CAGACAAAGG AGGCCCAGGT GTAGGTGGTC TACCAGGTGG TTGTGGAGCT 60

CT 62

(2) INFORMATION FOR SEQ ID NO:21:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 195 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: both
(D) TOPOLOGY: both

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

CCGCAGAGCA CCTCCACCAT CTCCTTGTCC TACTCCAAGA TCTGGCCCTA GTCCATGTTT 60

GCCTACACCA GATCCTCCTC CAGAACCAAG TCCTACAGGT TGGGGACCAC CAGATGGAGG 120

TAGAGCTGCA CTTGTACGAA GAGCTCCACA ACCACCTGGT AGACCACCTA CACCTGGGCC 180

TCCTTTGTCT GACGT 195